ALL ABUOT AIRSHIPS

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AUTHOR'S NOTE

In the preparation of this book I have received valuable assistance from many people, and I take this opportunity of thanking them for the courtesy they have shown me in supplying information or illustrations.

I should like particularly to thank the editors of *Flight*, *The Daily Telegraph*, *The Strand Magazine* and *The Morning Post* for permission to quote from their columns; Mr. Claude Grahame-White for his interview; and the managers of The Aeronautical Syndicate, Limited, makers of the British "Valkyrie" monoplane, for permission to view their machines under construction.

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ALL ABOUT AIRSHIPS

CHAPTER I

How Men Thought of Flight

A WHITE cliff, towering above a blue sea; sunshine and sky; and a great concourse of gulls, wheeling and swooping and gliding—for him who would study the grace of flight, those are the best surroundings. A gull shows us the beauty of flight better than does any other bird, and in many ways its mode of sailing the air approximates most closely to human methods.

Lie on the brow of such a cliff, and watch the great birds, wings held still, sweeping sheer down, tilting, wheeling in a splendid curve as they kick little spurts of spray from the wave-tips, rising again with scarcely a flutter of their wings and gliding to a boulder top as gently as falling flakes of snow. And then, if you have a taste for aviation, and if the magic of flight appeals to you, you will know why men first longed to fly.

For many centuries men have watched gulls and other birds, and have yearned to imitate them, and to rule the air as they rule the land and sea. The ancient Briton could swim, run and climb; yet, maybe, across his savage mind there flashed sometimes a wish for wings. The labourer plodding wearily home over the fields with birds

fluttering past him; the traveller faced by an impassable torrent; the hunter hard pressed by a wounded beast of the forest—at one time or another all these must have longed for the power to fly. And if but few attempts were made to learn the secret of the birds, it was because ancient methods were too crude to give the remotest chance of success; and because superstition too often discouraged scientific experiment by means of ducking stools, and stakes!

But we have ample evidence that the ancients sometimes considered the possibility of flying. There is, for instance, the well-known legend of Icarus, who by all accounts must have been a somewhat rash young airman. The sun, you remember, melted the wax with which the wings were secured to his body, and the result was a decidedly steep *vol plané*, of the most spectacular description, ending, as our American cousins might say, in a splash!

The idea of wax and wings was certainly far-fetched; but the story may have had a remote foundation of truth, which has been distorted into a fantastic fairy tale. Icarus may have been experimenting with a parachute, for instance, from the roof of a temple, and superstition and the priests would have supplied the picturesque details that were handed down to posterity. Be that as it may, it shows us that the old nations had bird-emulating ambitions, and when we read again of one Archytas, who made a toy pigeon that flew, we can see how far back aerial invention really extends. But men were too heavily handicapped

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in those days to dream of success. The world was not ready for flight.

Nevertheless, we may date the beginning of the serious struggle with the problem from the year 1214, and the man who first threw down the gauntlet before the giant of mystery was Friar Roger Bacon. The friar was a thoughtful man, given to deep pondering on most subjects, and fond of performing experiments with chemical apparatus, making gunpowder, and speculating on scientific matters generally. To him the sight of white clouds—heavy-looking affairs—drifting overhead, had suggested many wonderful possibilities. The sailing of these clouds was curiously like the sailing of ships, and the friar evolved the theory that there was in actual fact a sea of air, on which it would be possible to float in special machines, once the few thousand feet separating the cloud-banks and the earth had been traversed. The difficulty was, as Bacon saw, to devise this special machine—and it must be confessed that, with reasonable difference, his idea is quaintly suggestive of the modern Zeppelin airship.

"A large hollow globe of copper, or other suitable metal, wrought extremely thin, and filled with liquid fire." That was the substance of Friar Bacon's recipe for an airship, but apparently he never attempted to construct it, which, for his peace of mind, was perhaps just as well. Curiously enough the next historical attempt to guess the secret of flight was also made by a monk, named Lana, whose ideas ran in the same channel as had Roger Bacon's four hundred years before. He

decided that in order to cruise over this invisible air-ocean men must construct a boat, on ordinary lines, with a mast and a sail. To lift this boat, four large copper globes were to be employed fastened by ropes, the globes having been previously made lighter than air by being emptied of the air they contained. Needless to say, the invention got no further than pen and ink would take it.

But there were not wanting, even in those days, men who were willing to try their crude inventions in the air, and in 1508, Abbot Damian, with daring thoughts of a cross-Channel flight, announced that he would fly from Stirling Castle, in Scotland, to France, by means of certain wings, made of birds' feathers, which he attached to his sides. His attempt ended in disaster, and a broken leg ; yet, when he was picked up, forestalling perhaps the words of the philosopher, Francis Bacon, to the effect that " feathers doe possess upward attractions," he proclaimed that had his wings been provided with eagle's feathers the accident would never have occurred ! Damian was evidently an enthusiast, and were he living now would doubtless be in the front ranks of airmen !

Even these dark ages had their imaginative men, who believed that human flight was not an impossible thing, although they had but vague ideas as to the manner in which it was to be perfected. Alchemists, scientists, dreamers—the subject fascinated them all, for it is quite likely that they saw in success a certainty of stupendous power over their ignorant brethren. Imagine the

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effect that would have been caused by the appearance of a balloon over the field of Agincourt, or the smoke-reek of the Armada's destruction! The whole world would have been at the aeronaut's feet in those days, so that the secret was well worth seeking.

But it is to be expected that, knowing nothing of aero-dynamics, or aerostatics, aeronauts should have let their imaginations run a little wild at times. This, in fact, did happen. Some of the monstrous designs for aerial craft that have come down to us seem to reflect the very atmosphere of those ages—the atmosphere of the torture rack, the glowing brazier and the robed "wizard." There is a depressing effect about the designs, and the queer, dragon-like things well illustrate the gropings of the superstitious, imaginative mind.

Perhaps because of its artistic possibilities—dreams of metal serpents breathing fire and smoke over the heads of a cowering populace—the problem of aviation attracted, among others, one of Italy's most renowned painters, Leonardo da Vinci.

He designed a flying machine, in which he probably placed the greatest faith, although, as far as we know, it was carried no farther than the "working drawings." His machine was furnished with collapsible wings, opening on the down, and folding on the upstroke, in order to do away with unnecessary resistance. Thus it is evident that, however wild the general notion may have been, the machine embodied the result of some serious thought.

The records of the years from 1600 to 1700 give us quite a number of attempts to solve the problem of the air. Francis Bacon, the famous philosopher, among others, turned his attention to aerostatics, and wrote learnedly on the subject. It would have been better for his reputation had he kept his theories for private use only, for he attributed the flight of birds to the sole fact that Nature had clothed them in feathers. This after a deal of profound reasoning!

In the year 1617, two men turned their attention to aeronautics. One was a German schoolmaster of Tubingen, named Fleyder, who delivered a lecture on the art of flying, and, so to speak, gave away the secret for the benefit of all and sundry. The lecture was afterwards published, but no one appears to have profited by it. Doubtless Fleyder was highly venerated for his work; but what should we think nowadays of a man who lectured on the art of making oneself invisible, without proving his word by experiments?

The other man of the year was an Italian, Fauste Veranzio by name, who deserves a small round of applause. He, at any rate, did make a practical attempt, and actually drifted down from the tower of St. Mark's, in Venice. Doubtless his machine was some kind of parachute, and he must have been a brave man to trust himself to it. We can believe, too, that the sight on the occasion of his descent was a wonderful one: crowded gondolas, wondering lords, signors and peasants, filled with superstition, crossing themselves, maybe, and above, against the blue sky, the daring airman

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drifting down beneath his bulging parachute. In these days a flying meeting is not so picturesque.

England, too, was not behindhand, in those times. An English monk, named Elmerus, used a parachute with safety in Spain, and a Turk in Constantinople is said to have followed his example.

It is curious, by the way, to note that the majority of these early aeronauts were monks. Perhaps the reason lies in the fact that they were the most educated, and, therefore, the most thoughtful of the populace. They had time to dream in their cloisters.

Thus, we have John Wilkins, the Bishop of Chester, who turned his attention to the subject, and made suggestions for a primitive flying machine. He went farther than this, though—farther, indeed, than any of his contemporaries. He must have foreseen the era of the motor engine, for he prophesied openly that the time would come when men would fly as a regular thing, and moreover, suggested that an aerial machine might be driven by steam—a remarkable advance for the dark ages. Lack of knowledge and resources, of course, prevented his idea from being put to the test.

This is not to be wondered at when we remember that those were the days when the alchemist and sorcerer carried on lucrative practices. We read that one "wise" man, Laurentus Laurus, stated, in perfect sincerity, that if swans' eggs were filled with sulphur and exposed to the sun, they would ascend at once. He did not mention why ducks' eggs or ostriches' eggs would not do as

well. But it is easy to understand that when such ideas as these were entertained by scholars, so-called, a prosaic suggestion concerning steam, which anyone might see billowing from the boiling pot on the fire, would be disregarded entirely.

Then there are legends of a working model, exhibited by one John Muller, before Emperor Charles V. at Nuremberg. Very likely this was some toy or other, but the details are not known.

In 1680, a more scientific investigator appeared on the scene in the person of Borelli, an Italian. His work has a right to consideration, for it was conducted upon honest lines of inquiry. Perhaps it had been suggested by Leonardo da Vinci's design for a winged machine, or by the various dreams of flight that may have been entertained by the learned men of the day. Be that as it may, Borelli, taking the right line of scientific work, proceeded to study the flight of birds. Ultimately he made calculations of the strength of the pectoral —that is, the wing—muscles of birds. His inquiries led him to declare that men had not sufficient strength to fly by their own unaided efforts, with artificial wings. Inventions such as da Vinci's were useless, he said, and a fond castle in the air was ruined.

Borelli was undoubtedly right in stating this. Man is not built for natural flight by his own muscular power. Otherwise, he would have been provided with wings, grown a chest at which the broadest Guardsman must have wondered, and had the size of his head reduced to that of a large apple. In other words, he would have been

more bird than man, and might even have been clothed in feathers!

But Borelli did not perhaps see that there were other ways of applying muscular effort besides that of using wings, pure and simple. Engineers transmit and increase their power through the employment of cogs, and gearing. So it remained for a locksmith, named Besnier, to demonstrate, in the year 1678, that muscular power could also be increased by transmission through intermediate channels, instead of being brought directly to bear on beating wings.

His trade had taught him the use of metals, and something of the use of simple machinery and its manufacture, and, fired with the air-fever, he constructed an outfit of wings, on peculiarly novel lines. These wings were shaped like the double-bladed paddles of a canoe, the blades being hollowed and of considerable size. They were placed, one over each shoulder, in the slope-arms position of the modern infantryman, and the rear blade of each was connected with straps to the leg.

The aeronaut, if he were bold enough, now cast himself into space from some eminence, like the gliding slope of the modern airman, and proceeded to flap the wings in a certain peculiar manner. We must imagine that this method wanted a good deal of thought and practice, for we are told that the left arm and right leg had to work simultaneously, followed by the right arm and left leg. This would seem to be a puzzling process, requiring a good deal of attention, more especially as a mistake might prove fatal.

Yet Besnier, with his quaint paddles, actually flew, in a heavier than air machine! By Herculean exertions he raised himself from height to height—a few inches or feet at a time, until he could even gain the roof of a house.

Probably this forerunner of Paulhan and Grahame-White was of unusually muscular build, for the exertion of wielding the paddles must have been tremendous. Nevertheless, he had pupils, and certain other inventors, who might not have been able to pick his locks, picked his brains instead, and copied his novelty for their own uses, though they did not have much success with it.

Besnier deserves praise for his attempts, no matter how crude they were. The famous Francis Bacon did not do so much for aviation as the simple locksmith. Theories of "upward attractions" were met with a real machine; and though, undoubtedly, theories that are correct are necessary, and nothing but helpful to the machine designer, theories which miss the target can only be harmful.

The dark ages, therefore, despite the slenderness of men's knowledge, were not without their aviation authorities. The desire to fly was stirring men's minds, even when it was so utterly remote from the likelihood of its being realized. And these early inventors had learned something of aerostatics, at all events. In their parachute experiments they had shown something of the power of a surface to support weights in the air. Borelli had commented on man's muscular unfit-

ness for flight. Besnier had shown, in a nutshell, a most important point—that men might use mechanical means to increase muscular power, just as they use levers to lift great weights; and this position was a step towards showing that men might disregard the muscular part of the work altogether, and rely solely upon mechanical means. as in the modern aeroplane. Bishop Wilkins had suggested the use of steam—which, among others, Ader and Maxim were actually to employ, centuries later, on their machines.

So that a little had been done, if not to further the progress of science in any great degree, at least to rouse men's interest in the problem of flight. And after a brief pause the year 1742 saw the Marquis de Becqueville carrying on further experiments with the parachute. His trials were of no particular importance, and were only notable for the undignified conclusion of one of his longest drifts. He had started from one of the windows of his mansion—probably in the gayest of courtier's attire—and after sailing over the famous Tuileries Gardens, he landed heavily on a washerwoman's bench, on the muddy bank of the Seine!

And then, alas for progress, in 1757 came a woeful set back, a reversion to the theories of the dark ages. A monk named Galien sought to dabble in the subject of aviation.

As a result of his many ruminations on the subject, he produced a book on the whole art of navigating the air, which was, to say the least of it, a little premature. Set forth in the boldest confidence in his tome were many novel theories,

and even calculations. But the application of them to practice led to results as absurd as any that could have been attained by filling swans' eggs with sulphur, and solemnly waiting for them to rise skywards.

For Galien proceeded to state seriously that it was possible to build an airship as large as a town, with sufficient accommodation for the trifling number of 4,000,000 passengers, with all their luggage. This vast aerial city was to float gaily over Europe, with perfect ease and safety—but the town found no architect!

As a modest contrast to Galien's preposterous ideas comes the experimental winged car of another French courtier, named Blanchard. The famous Champs Elysée in Paris was the scene of his endeavour to mount into the air. He was the object of much chaff and spiteful ridicule, hurled at him by other courtiers, who gathered in a gay and laughing assembly on the terraces to witness his "rolling" practices. His experiments were all fruitless, and before long the Court became weary of these vain endeavours—as did Blanchard himself.

Yet, had he but known it, the day was very near when these same courtiers would hear with wonder, and many incredulous exclamations, of the first actual flight of men—of the real beginning of aeronautics, and that in their own land of France, too; of a flight more earnest than de Becqueville's fall into a washing tub; more daring than Blanchard's trips over the green turf of Paris.

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For, in 1776, one Cavendish was working at the problem of hydrogen, and a Dr. Black, of Edinburgh, had even suggested its use in light bladders, in order to raise them from the ground; while Cavallo, in 1782, filled soap bubbles with the gas and watched them rise swiftly, and drift away. Men were on the borders of the land of aeronautics, and in 1782 the famous Montgolfier brothers stepped over the dividing line between theory and practice. The dreams of men were realized, and the first airmen, in the true sense, had arrived.

CHAPTER II

The First Airmen

In the year 1782, at Annonay, a quiet country town, not far from Lyons, lived the two brothers Stephen and Joseph Montgolfier, paper manufacturers, and more or less stay-at-home men. Neither had made any stir in the realms of science; neither of them foresaw, probably, the results of the inquiries into aerostatics, which they were at that time conducting. Yet it was not long before they succeeded in raising a paper bag from floor to ceiling by rarefying the air within it by means of heat, obtained by holding the balloon over a chafing dish—a trivial result in itself, but with far-reaching effects.

It has sometimes been said that this result was obtained by means of a lucky accident, and that nobody was more surprised than the brothers themselves when the bag escaped from their fingers, and sailed on its maiden voyage to an elevation of some feet. But other authorities have alleged that this was not the case, holding that the brothers were thoughtful men, who had, for some time, been pondering on the subject of aerostatics, and had made their experiments as a direct result of their work. All the more honour to the Montgolfiers if this were the case. It is better to track a secret scientific-

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ally to its source than to stumble upon it unexpectedly.

Be that as it may, the indisputable fact remained that the brothers had manufactured a successful, if Lilliputian, balloon, and the experiment was the well-laid foundation stone of a rapidly growing edifice. Almost at once the Montgolfiers found and overcame their first difficulty—that of keeping the balloon in the air for a long period.

As the air cooled, the aerial craft, of course, descended. The obvious way of getting over that state of affairs was to keep the air hot. "How is it to be done?" said the brothers, and the answer was supplied by procuring a small dish, filling it with glowing charcoal, and tying it to the neck of the balloon. A few experiments on these lines led to complete success, and resulted in the construction of a successful balloon of 600 cubic feet in capacity, a really heroic size for those early steps.

By this time the story of all these mysterious experiments had naturally become more or less public property, and tremendous excitement and much incredulity was evinced by the peasant population when it was announced that a balloon of 35 feet in diameter, and of 23,000 cubic feet in capacity, was to be launched into space from Annonay in June. Everyone was soon chattering about this monster. Tongues clacked unceasingly, and there were not wanting those who denounced such proceedings as impious and improper. But, in spite of this, curiosity gained a notable victory

over superstition, and on the day of the ascent hundreds gathered to gaze in amazement at the spectacle of a great linen bag, swaying and plunging like a live thing in the grasp of half a dozen men, and bellying out, taut and plump, as the fire, kindled in a pit below the open mouth, rarefied the air in its interior. Cries of astonishment followed the balloon when at length it rose skyward. Necks were stretched and wide eyes stared, until after a voyage of over a mile, it fell gently to earth again, and the Montgolfiers had demonstrated to the satisfaction of everyone that "aerial floating," if not flying, was a possibility.

Incidentally, it may be mentioned that the peasants who found the balloon on its descent attacked it savagely with scythes and pitchforks, in the belief that it was some savage and horrible animal. On the whole, it is just as well that it carried no aeronaut!

You can imagine the excitement that this ascent caused, for such a thing had never been known before. It was not long ere the citizens of Paris were clamouring for an opportunity of beholding this new monster, and raising public subscriptions to bring the Montgolfiers to the town. But Paris is nothing if not up to date, and the people there showed the fact in a notable way by urging on the brothers, when they arrived, that hydrogen, the newly discovered gas, might be employed instead of fire, to raise the balloon.

The Montgolfiers acquiesced at once, filled a large balloon with the gas made by the action of

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sulphuric acid on iron, and had the satisfaction of seeing it rise from the Champ de Mars to an unprecedented height, before the eyes of a very large gathering.

Once again the absence of an aeronaut proved fortunate, for the experimenters yet had to learn that as the balloon rises higher the air becomes more rarefied, and the pressure of the hydrogen within the envelope correspondingly greater. They had sealed the neck of their balloon, and when in cloudland it burst, eventually reaching the ground in pieces. But the lesson was not ignored in future experiments, and the way was now open for the inauguration of passenger trips.

After this it is rather undignified to read that the farmyard supplied the first aeronauts! A big hot-air balloon, shaped rather like a lemon, and gaily decorated, was supplied with passenger accommodation in the shape of a wicker cage, and launched from Versailles before the eyes of the King and Queen of France. Swinging in the cage beneath the envelope were a sheep, a duck and a cock. A half-mile voyage produced no ill effects on the passengers, save for the fact that the cock had one of its legs fractured—doubtless in landing, which is always the most risky part of an aerial excursion.

This was enough for Monsieur Pilâtre de Rozier. In November, 1783, behold him, with a noble companion, Marquis d'Arlandes, standing on the wicker gallery below a swaying balloon 74 feet in height. Beneath the open neck of the envelope is an iron brazier, swinging from chains,

and billowing smoke into the cavity; on either side of this are the two aeronauts, piling fuel on the flames, and keeping wary eyes, too, upon certain wet sponges that they have brought for use as fire extinguishers, just in case of awkward accidents.

"Let go!" and amid cries of excitement the balloon rises, coquettes with the breezes, settles upon one particular air current and drifts away at a height of 3,000 feet on a voyage of some few miles. This first free voyage is destined to prove thrilling. The balloon drops uncomfortably near to the surface of the Seine, and frantic haste is made to replenish the fire. It rises again, sluggishly, and the interesting discovery is made that sparks from the brazier are burning numerous small holes in the envelope. Then it threatens to descend with some violence on the Paris roofs, but is finally conned to safety, and the two aeronauts have made their niche in the world's history.

After this events began to move rapidly. Two rival aeronauts appeared in the persons of MM. Charles and Robert, who came on the scene with a valved hydrogen balloon, made of silk, and supplied with various scientific instruments—a great advance on the crude hot-air machine. Before large crowds of Parisians they proceeded on a plucky and record-breaking voyage to the clouds, and descended safely. Charles then piloted the balloon alone, and reached an elevation of 10,000 feet before descending—a splendid achievement, which was followed by other voyages, one

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over a distance of 150 miles. Thus ended the first aeronautic year.

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Aeronautics had now taken a firm hold upon the public imagination, and England was soon to see ascents made in public. In the British Museum there is preserved a quaint printed handbill, containing a notice of an exhibition of the Montgolfier balloon in the Strand. "The grand aerostatic globe of the immortal Montgolfier" it is called, and the public are entreated not to miss this "immense, sublime and most brilliant spectacle, at the price of one shilling." "This brilliant and most magnificent spectacle," says the bill, "is doubly overlaid with gold! Upon it beam with refulgent glory constellations of stars, and all the planets of our Solar System!" Such is the modest description supplied to attract visitors, and it is possible that after reading this, the latter were disappointed with the aerostatic globe. The exhibition of the Blériot cross-Channel monoplane in London recently did not occasion a tithe of such dictionary searching on behalf of the advertisers!

Ascents now became more or less common events. In June, 1784, the first lady aeronaut voyaged to a height of 9,000 feet in a hot-air balloon. Her name was Madame Thible, and the journey was made at Lyons before King Gustavus III. of Sweden.

The little silver streak of the English Channel early attracted balloonists. M. Blanchard and Dr. Jefferies, an American, started to cross it in

1785, from Dover, using a hydrogen balloon. An early and unforeseen descent led to their casting from their car every loose weight they had, including articles of clothing. But eventually, after a narrow escape, they landed on the French coast, having erected another landmark in aeronautical history. It was Blanchard, by the way, who made the first attempt at a dirigible, and the British Museum contains a woodcut of his balloon, fitted with sails and oars, with which he intended to steer his way across country, showing that he was not only plucky, but original.

Ascents were now becoming frequent in Europe. Previously to Blanchard's voyage, an Italian, named Lunardi, made an ascent from London, descending near Ware, and causing considerable consternation among the labourers by his appearance from the skies. This was one of the historical voyages, and the place of descent is marked to this day by an inscribed stone.

Then came the first toll of life taken by the air. The famous Pilâtre de Rozier with a friend, M. Romain, wished to emulate Blanchard's feat of crossing the Channel, and, disregarding all scientific truths which might have been urged upon him, decided to use for the purpose a machine which was a combination of a hot-air and a hydrogen balloon. The ascent was made safely from Boulogne. But when at a good height from the ground the balloon exploded, and both men were dashed to pieces. They had run the most incredible risk, possibly in ignorance, and had paid the penalty.

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So far, accidents with balloons had been unknown. Save for the fact that they were uncontrollable, these gently drifting globes seemed to be as safe as any mode of travelling then invented, safer than ships at sea, and far more comfortable than diligences on the hard roads. But there were always possible risks to be taken into account, and bearing this in mind, one or two men began to turn their attention to safety devices.

A kind of lifebelt was sought to which an aeronaut might safely entrust himself in time of danger; and in the parachute it seemed that such an apparatus had been found. In 1797, M. Jacques Garnerin announced that he intended to make a descent with a parachute of his own device, and, providing himself with a hydrogen balloon, he rose to a considerable height, and then, cutting himself free, dropped. A cry of horror went up when his meteoric fall was witnessed. But in another moment the parachute unfolded like a cloud above his head, and his descent was checked. Swinging gently, he drifted down, landing in perfect comfort, after a journey which must have been a little thrilling to a "novice."

But meanwhile the balloon had been turned to other uses. In the year 1794 we find it, imperfect and little known though it then was, making its début in a more practical way. So far it had only been used for exhibition purposes, to strike wonder into an open-mouthed populace, and earn its owner a reward for his daring. But now, the French, with that quick imagination which is one of their greatest characteristics, began to search

for a mode of applying the invention to their own benefit, and military men were quick to see the possibilities that it held. Let us look back, for a moment, and imagine ourselves with the lines of the French army near Fleurus, opposing the Austrian forces. . . .

The muddy lanes are packed with scarlet-coated infantry and cavalry; away to right and left shine the guns of the artillery, and in the distance a rattle of musketry, drifting over the fields, announces that the engagement has begun. With a clatter of hoofs, staff officers, with nodding plumes and glittering sabres, pound swiftly past, spattering storms of mud in their wake. Wagons and tumbrils trundle forward. Hoarse orders are rasped out.

And then, into this almost mediæval picture of massed infantry, in squares and columns and gay uniforms, comes a herald of progress. Towed by an armed company in blue, with Captain Coutelle in command, a pellucid, silvery globe approaches, bobbing and swaying in the breeze above the heads of cavalry and infantry, dipping this way and that. Thus has it been tugged from Mauberge to Charleroi, thirty miles across country; and now it is going to prove its worth.

An order, and the company halts. A minute later, with that typical, soaring motion, the balloon is rising, and from its car keen eyes are surveying the wide stretch of country that opens out below. Something falls from the car to the turf, and an orderly gallops forward, retrieves the object, and returns it to a Staff Officer. It is a

plan of the Austrian positions, and in half an hour the French infantry are being marched out to face them. Thud! Thud! The Austrian cannon are making vain attempts to hit this strange target. But it is out of range, and floats quietly and peacefully over the country while the French win the battle, largely owing to its presence. For the first time, the balloon has testified its usefulness in war.

After this we read of its employment constantly. In 1799, at the siege of Mainz, Coutelle ascended before the enemy's guns, in a remarkably strong wind, making observations which were of considerable value. And Napoleon himself attached so much importance to aeronautics that, when he sailed on his ill-fated expedition to Egypt, he arranged for a balloon to accompany him. It did not reach its destination, however, for an English frigate fought and captured the ship in which it was being carried, and the age-old, dusty plains, hallowed by antiquity's lore, were destined to be uncrossed by the shadow of an aerial machine for some time to come.

Then again, mention of war balloons was made in the year of 1812, on the occasion of Napoleon's historic march over the snows of Russia, ending in fire and death-haunted retreat. The Russians at Moscow, in desperation at their threatened plight, with a mighty veteran army marching upon them, which they had no chance of stopping, are said to have built a balloon of heroic size, intended to lift fifty passengers, who would be able to direct a shower of bombs upon the attacking

infantry. Owing to some fault in construction, however, the balloon was an utter failure, and the Russians had to resort to the plan of destroying their fine town by fire. In any case, it is doubtful whether one balloon would have shaken the courage of Napoleon's famous Guards. But it can be seen from this that even in those wars, which text books are not accustomed to associate with much that is modern, the aerial age had its beginnings.

Meanwhile, notable progress had been made in "civilian" aeronautics. Guy Lussac, a French savant, had succeeded in ascending to the then unprecedented altitude of 23,000 feet, where he found that such modern inventions as a hot-liquid flask and an electric heater would have added to his comfort. He was benumbed and miserable. Yet, in spite of this, he managed to make various valuable scientific observations, before he descended safely at Rouen.

In 1812, a Mr. Sadler attempted to cross the Irish Channel from Dublin to Liverpool. The idea of the voyage shows that he was possessed with a taste for adventure, and this taste must have been amply satisfied by the time his trip was over! When nearly across the Channel, after an uneventful voyage, he met a contrary air current and was blown back to sea again, and after vain attempts to find a friendly drift, was forced to descend into the cold waves, within a mile or so of a vessel, which was tacking towards him.

His balloon, however, was not to be caught so

easily. It bellied out into the form of a sail, and in a few minutes Sadler found himself outdistancing the boat behind. In desperation, he divested himself of his clothes, tied them to the grappling iron, and threw the bundle into the sea, to act as a drag, without much result. He then ripped the balloon, and immediately found himself sinking, in a maze of cordage and suffocating fabric, which, washed towards him by the waves, threatened to overwhelm him. A frantic struggle for life followed, until the pursuing boat drew up, running her bowsprit through the meshes of the cordage, just as Sadler had fainted. Five years later, in 1817, the same aeronaut's son managed to accomplish the feat of crossing the Irish Channel, in safety.

And now, when the sight of a balloon no longer inspired fear in the minds of the country folk, we begin to find a few names standing out prominently in aerial history: Green, Wise, Glaisher, Coxwell, and others. It is impossible to deal here with all the ascents of interest that were made by these men, for their name is legion; but one of Green's early ascents is noteworthy from the fact that he used ordinary coal gas in his balloon instead of hydrogen, which was prohibitive, owing to its cost and to the difficulties of satisfactory manufacture. Perfect success attended the experiment, which was a source of gratification to all aeronauts, whom the expense of balloon-filling had previously worried considerably.

Green made one early voyage from Newbury in a thunderstorm. I wonder how many of my

readers, looking up at those angry, whitish cloud-battalions, rent now and again by streaks of light, would care to see an electrical disturbance at close quarters? Not many, I expect. But Green saw in his voyage great opportunities for interesting, and scientific, investigation, and ascended light-heartedly in a hurricane, amid a driving hail-storm, plunging out of sight in a few minutes, and rising above a packed mass of racing clouds.

Now and again, these were lit up by vivid lightning, and appeared to swirl, and contract, as the heavens roared and echoed with the riot of thunder. It was an awe-inspiring voyage, and Green must have been constantly on the look-out for accidents. He descended, however, in perfect safety, despite the strong wind.

Subsequently Green, with two companions, made a notable voyage of 500 miles in the famous "Nassau" balloon, from Vauxhall to Germany, travelling over France by night, without any untoward adventures. The trip lasted eighteen hours, and is one of the famous voyages of history. But from an adventurous point of view it lacks interest.

About this time, M. Nadar, in France, constructed a giant balloon, named after himself, of 215,000 cubic feet in capacity, and 74 feet in diameter, and fitted with a car containing two floors, with cabins, berths, a larder and a printing office. The first ascent was made with fifteen passengers from the Champ de Mars, and ended rather disastrously, the balloon dragging the car along the ground for nearly a mile before it was

deflated. A later voyage also ended in disaster, and the balloon was dismantled for exhibition.

Another name was soon afterwards added to the death roll of aeronauts in the person of Mr. Cocking, who met his terrible end in an experiment conducted with a parachute of his own invention, released from a balloon conned by Green. This parachute was shaped in the manner of an umbrella turned inside out—the reverse of the ordinary design. Cocking left the balloon at an elevation of over 4,000 feet, on releasing his parachute, and dropped at a terrific speed, pitching and swaying, being literally dashed to pieces on his descent. Previously friends had tried to dissuade him from his experiment, which they were convinced must end disastrously. But he had firmly placed faith in his invention, which served him so ill.

Messrs. Green and Griffiths, who were in the balloon above him, had an exciting experience also, being almost suffocated by the gas which poured from the balloon when, relieved of Cocking's weight, it rushed upwards at a horrifying speed. Cocking's feat was certainly of the rashest description, for he had made no previous experiments to test his theory, and the elevation at which he left the balloon was very great.

A scarcely less rash proposal was that made a year or two later by Green himself, who suggested that an attempt might be made to cross the Atlantic in a balloon, but was unable to raise funds for the voyage, fortunately for him, we should say.

Meanwhile, the next man whose name we have mentioned was making himself famous. That is John Wise, an American who was showing himself to be a plucky and keen aeronaut by many good voyages. Among other adventurous feats, he made himself famous by proving a truth which has comforted aeronauts for many years—the truth that accidents can rarely happen through the explosion of a balloon. It sounds rather a rash assumption to make, but Wise reasoned that the envelope of a ripped balloon would, when the rapid—unpleasantly rapid—descent began, crumple up in the top of the netting and form itself into a kind of parachute, without aid of any kind from the aeronaut. To prove his words, he heroically exploded a balloon in mid-air and descended safely to earth before an alarmed concourse of spectators. It is safe to say that he not only proved his theory, but also his pluck, by that experiment.

Like Green, Wise also ventured into the thick of a thunderstorm, and made observations of interest to the scientific student. He originated, too, the idea of tying streamers of ribbon to his trail rope to enable him to see the directions in which the air currents were blowing at different altitudes below him—a useful idea, of considerable importance to the aeronaut.

To the American's credit stands one of the longest balloon trips on record. In 1859, he started in a gale from the town of St. Louis, rose to a great elevation, and drifting off at a high speed, succeeded in travelling no less than nine

hundred miles in the period of nineteen hours, landing safely at Henderson, N.Y. For many years this was a long-distance record.

Meanwhile Green continued to make enterprising ascents in England, and the inhabitants of London became quite accustomed to the sight of his balloon, the "Nassau" floating far above their heads. Frequent trips were made from the famous old Vauxhall Gardens, a pleasure resort of past days, something like the modern White City, and Green showed a distinct love of sensationalism when he advertised that he would ascend in his balloon on horseback. This he did, to the great delight of the public.

Other voyages he made for the purpose of scientific and meteorological investigation, and though, as a rule, he met with few mishaps, he had at least one adventure, when, with a man named Rush as his fellow aeronaut, he descended from an altitude of 20,000 feet into the water, at the Nore. The "Nassau" touched water off Sheerness, and proceeded to sail out to sea before a stiff breeze, outdistancing the vessels which tacked to its help, just as Sadler's balloon had done in the Irish Channel. The aerial monster was finally hove to by means of the grapnel, and a Navy boat put off from one of the warships, and effected the rescue of the aeronauts. In order to deflate the balloon, however, it was found necessary to direct a volley of small-arm fire at it, when it collapsed like one of those dying pigs sold by modern street hawkers, and was dragged to safety.

During his fine career, Green made over one thousand ascents. It is interesting to note, too, that his wife, in company with a Mrs. Forrest, made the first ladies' ascent in England.

On Green's retirement, Coxwell and Glaisher succeeded to the top of the aeronautical ladder—in two senses. For not only did they become famous for their enterprise, but also for the altitudes to which they ascended on various occasions. Coxwell flinched from very little in the shape of weather, and went aloft in thunderstorms or hurricanes with equal zest, landing sometimes at prodigious speeds, in the most risky surroundings.

It must be noted here that in ballooning, and, indeed, in aviation of the modern description, it is the landing after a flight which is often the most dangerous part of a voyage. While it is beyond the reach of steeples and forests, your balloon will drift safely in the wildest tornado, scudding along on the wings of the wind, in company with the clouds above it. But when it drops to earth the half-deflated envelope becomes to all intents and purposes a sail, bellies out in the gale, and drags the car behind it, over streams, hedges and outhouses with the fury of the wild horses to which savages used to tie their condemned prisoners. On such occasions the aeronauts, clinging for life to the wicker-work, go through a distinctly wicked quarter of an hour, and are lucky to escape with jarred limbs and bruised muscles.

Coxwell tells of one exciting landing, which he made at a speed estimated to be at least sixty

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miles an hour, and that on rough ground. On that occasion he had a miraculous escape from injury. Another danger in descending is that of coming down in deep water. On one occasion, starting from London at midnight, Coxwell journeyed south, scarcely realizing his route in the darkness until, in the dawn of a summer's day, he discovered that he was close to the south coast, to the west of the Isle of Wight, with the sea shimmering peacefully before him. A few minutes longer, and he would have been voyaging out into the Channel, with no chance of making land, and very little of being picked up by ship. In the nick of time, however, he managed to bring his balloon to earth, and was able to congratulate himself upon an exceedingly lucky escape, after a five hours' trip.

Then, at the height of his fame, he went into partnership with Mr. Glaisher, another famous aeronaut. And here we must leave him for a little while, in order to turn back and give a short review of aerial progress in a different direction, before dealing with the record trips made by Glaisher and Coxwell, leading to the modern side of ballooning.

CHAPTER III

The Early Dirigibles

ALMOST from the very beginning of the balloon era men had been pondering over the problem of steering this aerial craft, which had given them at last the power to rise free from the earth.

In a balloon you are in a strange position. You are free from all companionship, out of hearing of the roar of traffic, and the song of life; drifting above billowing cloud-seas, with nought save your own shadow below to keep pace with you; free from danger and annoyance. Yet all the while you are more firmly bound in Nature's toils than the clumsiest railway train, clattering on steel lines, two miles beneath you. You are in the power of the gentlest wind current. It blows south, and southwards you drift, whether you will or no, unless you change your elevation and find the air trending in a different direction above or below you. The wind blows at twenty miles an hour, and however much you would like to enjoy the scenery, you cannot apply brakes to your craft. You are at the beck and call of the breezes, uncertain as to your landing place, and even as to your probable course, unless the air currents are setting steadily. Above all, you must go with, and not against, the air. You are helpless.

Very early in the history of aeronautics men were fully aware of the disadvantages of this position, and with a premature ambition, which was scarcely warranted by their powers, cast about them for some mode of steering, for some type of dirigible balloon, which they could take across country at will—though, as is natural, their dreams did not at first visualize a ship that would be able to travel in the eye of the wind. They had no knowledge of the motive power required to drive a balloon in that way.

We are accustomed to look upon dirigible airships as a very modern invention. Yet, as early as 1784 the brothers Robert, to whom I have already referred, attempted to steer their balloon in France. It is true that their methods were rather crude. They compare with the engines of the modern Lebaudy or Zeppelin just about as well as the ancient Briton's coracle compares with the *Mauretania* or *Olympic!* Nevertheless their attempt at balloon-control was a serious one, resulting in the building of a fish-shaped vessel, fifty-two feet in length, which was to be steered by means of oars. It must be confessed, however, that the success they attained is quite negligible!

All the same, some honour should be paid to them for having first suggested the idea of the dirigible, and for using a fish-shaped envelope, and thus lessening head resistance.

It was in the year 1812 that the next airship made its appearance in Russia. It was a quaint contrivance, shaped like a sperm whale, and provided with a kind of fin propeller, which was

operated by hand. It was known as the Leppig airship, and was a complete failure.

This was an unfortunate beginning. But, nothing deterred by these two unsuccessful attempts, Comte de Lennox went to work, and in 1834 produced a new type of airship. The envelope was cylindrical, and was 130 feet in length, presenting, it is to be supposed, quite an imposing appearance when inflated. The system of propulsion, however, was again at fault, consisting as it did of twenty oars, operated by manual power. The vigorous manipulation of these blades was intended to increase the speed of the airship, for it was evident that, if the airship or balloon could be made to travel faster than the air current in which it was floating, it would at once answer a rudder, as does a boat in a river. The idea was sensible enough, but this Lennox airship was destined to have an undignified end, since, on inflation, it was found to be too heavy to rise at all. An excited French crowd, gathered in festive garb to witness the trials of this aerial monster, considered this mishap to be a studied insult to themselves, and by way of improving matters smashed the airship at once! This was unfortunate, but at any rate, their action probably saved Comte de Lennox from the bitterness of disappointment, since it is not to be supposed that the machine would have fulfilled his expectations.

After this, there was a lull in invention, and for a few years nothing was done to further the balloon. But during this period men began to

realise that if the airship was to be a success, it was necessary for them to employ some kind of motive power, an engine of some kind, which would force it along at an appreciable speed ; and thus, at last, the first success was attained.

In 1852, a Frenchman named Giffard appeared on the scene with a cigar-shaped balloon, of novel design. Beneath the envelope a car was suspended, containing a steam engine of some three horse-power weighing about 100 lb., which drove a screw propeller. Special safety devices, in the shape of shields of iron gauze, were provided, in order to do away with the danger of explosion that might be caused by heat or sparks from the engine. Unfortunately, during a descent, Giffard's first balloon burst. He built a second ship, however, with rather a sharper outline, the envelope being some 144 feet in length, and with this he scored some success, travelling at a speed of some 8 feet a second through calm air, and causing his craft to deviate appreciably from its course by the operation of a triangular rudder, fixed in the stern. The inventor was thus encouraged to draw up plans for several more machines, of higher power and increased size, but owing to lack of money for carrying on experiments, none of these projected ships was built. Giffard died in 1882, and he deserves to be remembered as the true pioneer of the modern giant airship. His successes were not revolutionary ; but they proved, at any rate, that the dirigible was a possibility, and pointed out the way for subsequent inventors to follow.

Another lull followed. Then, in the year 1872,

Depuy de Lôme came to the fore. The ship which he designed was intended to be used for war purposes, during the siege of Paris by the German army in the Franco-Prussian war. As a matter of fact, however, the machine was not ready until peace was declared, and it is not probable that, had it been completed earlier, it would have had very much effect upon the Prussian troops. It was a fair size—110 feet in length—the envelope being spindle-shaped, and propulsion being given by a screw. Here, however, de Lôme's imagination was shown to be not as great as that of Giffard, before him, for the screw was operated by manual power, provided by a toiling crew of eight men. Steering was arranged for by the provision of a large rudder of sail-like description, and on its trial trips the machine did meet with slight success—not great enough, however, to encourage the construction of any more hand-driven ships. It attained a speed of some 9 feet a second in the most favourable conditions.

But in the same year a considerable advance was made by Haenlein, in Germany, both in the size of his cigar-shaped balloon, and also in its motive power. His airship, a sharp-nosed vessel, extended to a length of 160 feet. In the car beneath was a 4-cylinder Lenoir gas-engine, of 2 h.p., driving a screw propeller, and the machine was steered by a rudder. Another novelty is to be noted in connection with the engine, gas being supplied to it from the balloon itself, and compensation being provided in the envelope by the pumping of air into it. The conception of this

machine was altogether more workmanlike than that of its predecessors, and it succeeded in travelling at a speed of 15 feet per second, and obeying the helm. Lack of funds, however, again stopped the experiments, for the public were not sufficiently encouraged by the results to give much help to poor inventors.

These latter, however, had not yet given up hope, and in 1883 two brothers, Gaston and Albert Tissandier, built another dirigible, which possessed a novelty in the shape of an electric motor of twenty-four bichromate cells. The machine met with some small success, but the speed was poor —only 10 feet per second. On the whole, this dirigible supplied no advance upon former types, save in the employment of the electric motor.

The year 1884 saw a notable improvement in the construction and performances of dirigibles. Ever to the fore in matters pertaining to aviation, it was the French nation which furnished the next two inventors of airships. These were MM. Renard and Krebs, both officers in the army. In partnership, they built a large balloon, 165 feet in length and some 27 feet in diameter. It was shaped like a torpedo, and motive power was supplied by a strong electric dynamo driving a wooden propeller. Sliding on a rod below the envelope was a weight, which could be shifted by the aeronauts to adjust the balance and pitch of the ship—a useful device, adopted with modifications in various subsequent machines.

The trials of the balloon were exceedingly interesting. In calm weather it attained a speed

of 15 miles an hour, travelling steadily, and without any annoying pitching. The rudder was put over and, easily and gracefully, the ship responded, turning quietly, and heading back. Once more the helm was altered, and by the time the trials were concluded the balloon had succeeded in describing a figure of 8 in the air—a feat which no previous dirigible had been able to attempt with even the remotest chance of success. Subsequently, the balloon made several good voyages.

It was found, however, that its engine power was not great enough to make it an unqualified success. Its speed was low, and was easily nullified by even a gentle head wind, and so, eventually, it was abandoned, after having had a praiseworthy, though short, career. It was proposed at the time to build a larger sister-ship. But for some reason or other the latter never materialised, and it remained for other inventors to carry on the work which Renard and Krebs had so well taken up.

In 1887, Wolfert, a German, appeared on the scene with an airship, engined by a benzene motor. The ship carried three cars, and special provision for raising it vertically was made in the shape of a propeller placed directly underneath it. The engine was by no means the safest for use beneath a gas-filled envelope, and owing to this fact the luckless aeronaut met his death. He was travelling at an altitude of some 500 feet when the balloon caught fire, and fell, a flaming meteor of wreckage, to the earth, adding another name to the roll of inventors who had met their death in the attempt to conquer the air.

After this some time passed, during which no particular work was done in connection with the dirigible. Inventors were waiting for some better and safer motive power, which would make their ships efficient. Moreover, in spite of the number of praiseworthy attempts, save for the Renard and Krebs ship, few of the inventions had met with any encouraging success. Invention was hovering on the very threshold of efficiency; and only one more ship was to be built before the modern successful era of dirigibles was entered upon.

This was a machine made by an Austrian, of the name of Schwarz. It was a noteworthy departure from its predecessors in one very important respect. Schwarz had observed the disadvantages attending the adoption of the ordinary limp envelope for airships; and, very boldly, he set out in the year 1895 to remedy this fault by constructing a balloon with a rigid aluminium framework. For various reasons, however, his invention was a failure, and it remained for other workers to introduce the first of a series of workable airships, leading to the very latest types of to-day.

We must deal with these in a subsequent chapter. For during these years of invention, ballooning of the old description had made considerable progress. So, before the public were fully educated up to the fact that efficient dirigibles were possible, and that a real aerial age was dawning, many notable balloon voyages were to be made; and we must now consider these and show how knowledge of aeronautics developed, before describing the later dirigible airships.

CHAPTER IV

How Ballooning Developed

WHILE men had been searching for a mode of steering a balloon and driving it against the wind, ballooning of the simpler description had not been neglected. Considerable interest was being taken in aeronautics, and public attention was drawn to the balloon by reason of its employment in the American Civil War of 1861, and at Solferino, in 1859.

The success attained by these early war-balloons was so great that it at last roused the English War Office to action, and the year 1862 saw the establishment at Aldershot of the balloon corps under the advice of Mr. Coxwell. As has happened in all the history of aeronautics and aviation, the British Army had been behindhand in taking up the new idea. But the air corps was now set firmly on its feet, and was destined to become a recognised special body in the army after the year 1879, when Colonel Templer took over the command.

About this time, too, Glaisher and other aeronauts began to carry out a more detailed and careful study of practical aerostatics. Ascents were continually made with a view to scientific inquiry, and many valuable contributions were made to the knowledge of the balloon and its behaviour.

And here it will be as well to make a little detour for a minute, in order to touch upon the subject of aerostatics. The secrets of the balloon are not by any means so simple as the average person may think; it is true that the science of aerostatics, the science that deals with machines that are lighter than air, is not so involved as the science of aerodynamics, dealing with the flight of heavy machines. Nevertheless, the problem of the balloon is like one of those simple-looking algebra problems, which, before they are worked out to a conclusion, involve the most complicated changes of x and y. "Just fill a balloon with gas, and it rises; and there you are." That is aerostatics simplified by the unthinking amateur!

But, as a matter of fact, before you "just fill" your balloon, you have to consider a good many points. First of all, there is a certain law, known as Archimedes' law, which has to be borne in mind. This law states that "every body that is immersed in a fluid is acted upon by an upward force exactly equal to the weight of the fluid which is displaced by the immersed body." So that, if a balloon is inflated with any gas lighter than air, it will be pushed upwards by a force equal to the weight of air it displaces.

Coal-gas weighs just about half as much as air, and therefore a volume of coal-gas weighing, say, a pound, will be pushed upwards by a force of a pound, and so on. Hydrogen is considerably lighter than coal-gas, and whereas the latter will lift 40 lb. per 1,000 cubic feet, hydrogen lifts 74 lb. for the same volume of gas. But coal-gas

is generally used in balloons owing to the difficulty and expense of manufacturing hydrogen on a large scale.

Before constructing a balloon, therefore, the aeronaut has to calculate the cubic capacity of his envelope, and regulate the weight he wishes to lift accordingly. As a rule, a balloon of 45,000 cubic feet capacity will lift three or four people, but a craft intended to ascend to great altitudes must be of greater size, in order that allowance may be made for the leakage of gas, which is unavoidable. And the same allowance must be made for balloons that are intended for long-distance voyages. The aeronaut will make his balloon spherical, because the sphere will contain the greatest volume of gas in the smallest surface, and he will have to allow lifting power for the carriage of ballast. This, as my readers probably know, is usually in the shape of sand, and is taken up for the following reason.

As a balloon rises the pressure of the air outside the envelope becomes less, and the gas contained in it expands, eventually overflowing, until the balloon arrives at what is known as a state of equilibrium—where it will no longer rise or fall, but float steadily, without losing gas. In practice, however, it usually overshoots this mark, owing to its momentum, and then begins to sink back again.

This sinking momentum causes it to drop below the stratum of equilibrium, overshooting it once again, and it then rises—and would continue thus to rise and sink, were it not for ballast, which,

being thrown out in small quantities, so regulates the lift that the balloon may be kept steady.

It is important to check the sinking motion, for if this is not done air will enter the balloon by the neck, and it will then lose some of its buoyancy ; and under normal conditions a balloon which has descended, will rise to a height equal to that from which it has fallen, when the gas will again begin to overflow, as it expands. An aeronaut must, therefore, be well acquainted with these, and other, laws, in order that he may be able to use his ballast judiciously, and be able to make protracted voyages. The recipe for long voyages is to keep low at the ascent, and out of the sun ; to avoid using the escape valve, and the ballast, while keeping the balloon steady, and to endeavour to make the trip in an ascending straight line.

I have mentioned here that it is necessary to keep out of the sun. The reason for this may be understood from Guy Lussac's law, stating that all gases are equally expanded or contracted by the same variations of temperature. Heat causes gases to expand, and if your balloon is drifting low beneath a cloud bank, and should suddenly float into a blaze of sunshine, the gas instantly expands, as the envelope is warmed, and the balloon rises quickly, until perhaps the gas is overflowing with great rapidity, and the balloon is losing buoyancy.

In the same way, a fall of temperature—the sun veiled by a cloud—will cause the balloon to sink. So that it can be seen that the navigation of a balloon requires a deal of technical knowledge

and keen observation, and it can be understood, too, that a day of alternating cloud and hot sunshine is exceedingly unsuitable for the aeronaut.

It must also be noted that a balloon is an exceedingly delicate machine, and is so exactly equipoised in the air that the smallest loss of weight will cause it to rise to apparently disproportionate heights. An aeronaut named Tissandier, for instance, relates that on one occasion he threw out of his car a chicken-bone, and that his craft immediately soared to a distance of 90 feet above its former level! And, of course, there are many instances on record of aeronauts, hard-pressed, sending their instruments overboard, and their clothes, too, in order to avoid a catastrophic descent.

All these facts, of course, were understood by Glaisher and Coxwell. They had been puzzled out by aeronauts and scientists in previous years, and the simple balloon of the Montgolfier brothers had received many improvements. John Wise, the American, for example, had introduced the ripping panel—a strip of material sewn on the inside of the envelope to a rent in the balloon, to which is attached a long cord, passing down to the aeronaut in the car below. Its object is to tear the envelope without spoiling it completely, and so to liberate the gas rapidly, in order that landing in a strong wind may be unaccompanied by danger. If the balloon is not deflated, the envelope, as I have pointed out, acts as a sail, and the aeronauts may have a bad time of it!

In 1820, Green began to use the guide rope.

Doubtless my readers have at some time or other seen this long, spidery cable hanging below the car of a balloon. It is used to keep the craft at a more or less constant altitude. When the balloon ascends the dead weight of the rope checks the rise; when it falls part of the weight of the rope is taken by the ground below—checking the descent. A valve is also fitted to the top of the envelope to allow gas to escape in small quantities, at the pleasure of the aeronaut, who may wish to stop a lofty climb by reducing the buoyancy of his balloon.

Thus Glaisher was well equipped with means to follow out his scientific work, and not only equipped with instruments, but also with that love of accurate investigation which it is necessary for a scientist to possess. He regarded the balloon as something far superior to a toy, or a machine to be used for merely exhibition purposes. It was to him a means by which valuable meteorological observations could be carried out; by which he could compare the effects of mountain ascents with the effects of ascents on aeronauts, could probe the mysteries of density, temperature and pressure, and investigate electrical conditions at varying altitudes. The effects of diminished pressure, too, on human beings, interested him. And before long he was to have ample opportunity to make observations with regard to this side of ballooning, in company with Coxwell. The ascent which enabled him to do this is historical, and is worthy of considerable attention.

In 1862, the aeronauts made one ascent for

scientific purposes, during which they reached the giddy altitude of 22,357 feet. They took up with them a very large number of instruments, and on their way were enabled to make various interesting observations with regard to temperature variations. Their landing was violent, so that nearly all their instruments were smashed.

Undismayed by this, however, the intrepid aeronauts ascended a few weeks later, from Wolverhampton, with the sole idea of climbing to the greatest possible altitude, and before touching earth again they were destined to live through some unpleasant moments.

Rising swiftly, they sailed to a height of 5,000 feet above mountainous masses of clouds, dazzlingly bright in the sun, which, in Glaisher's own words, "charmed the eye with alternations and brilliant effects in light and shade." These clouds lay in exceedingly thick piles, and it was some time before the balloon rose free of the misty ravines and precipices. After twenty-five minutes of steady climbing, however, the instruments recorded a height of three miles above sea-level. It was very cold up there, the thermometer having sunk to 14 degrees below freezing point; but it was to drop considerably lower before the journey came to an end.

In three-quarters of an hour from the start, the aeronauts found themselves hovering at a height of five miles, in a temperature of 2 degrees below zero, and now both of the voyagers began to feel acutely the effects of the greatly diminished air pressure. It must be remembered that they

were not provided with the oxygen cylinders, which modern aeronauts can take up to ease their breathing, and in the attenuated air their hearts and lungs were being taxed very severely. Nevertheless, with superb pluck they continued the ascent, even throwing out some of their ballast, and shooting up still farther above the sea level. Glaisher then found that his sight was impaired. He was scarcely able to read his thermometer, or his watch, but managed to decipher the barometer and found that it registered an altitude of no less than 29,000 feet !

His own words are eloquent of the discomfort of travel in these lofty regions. "Shortly after," he says, "I laid my arm upon the table, possessed of its full vigour ; but on being desirous of using it, I found it powerless. . . . Trying to use the other arm, I found that powerless also. Then I tried to shake myself, and succeeded, but I seemed to have no limbs. I struggled and shook my body again, but could not move my arms. Getting my head upright for an instant only, it fell on my right shoulder. . . . Then I fell backwards. . . . I dimly saw Mr. Coxwell, and endeavoured to speak, but could not. In an instant, intense darkness overcame me, so that the optic nerve lost power suddenly."

After this he became unconscious, finding that respiration was exceedingly difficult and painful.

Meanwhile, however, Coxwell had been having his thrilling moments also. It happened that the valve line of the balloon had fouled in the ring, and despite the difficulty of making any motion

and the freezing, biting cold, it became urgently necessary for the aeronaut to mount to the ring and set the line free. He climbed up, therefore, with the greatest caution—knowing that the result of a slip would be too terrible to contemplate, clutching at the ropes with numbed fingers, and breathing hard, as he ascended.

The cold was frightful. His head was singing, and he had to work desperately to clear the line, before he became unconscious, as Glaisher had already done. It was a terrible position—up there in the remote, icy stillness, fighting for life; and so keen was the air that Coxwell found that his hands were frost-bitten, at the moment when he succeeded in freeing the line.

His fingers were numbed, stiff, and useless, and he was still clinging to the ring above the car. Then, glancing below, he saw that Glaisher was senseless, and being anxious to help him, prepared to descend as best he could. To do this he had to resort to desperate measures, resting his arms on the ring, freeing his feet, and dropping. Fortunately, he landed safely in the car. He knew that any further ascent might well prove fatal, for he himself was fast becoming dazed and weak; and still the balloon was mounting. His hands were useless, and in desperation he turned to the valve line, seized it in his teeth, and by bending his head, managed at last to open the valve, thus freeing a certain quantity of gas, and causing the balloon to begin its long descent.

"Again," says Coxwell, "on letting off more gas, I perceived that the lower part of the balloon

was rapidly shrinking, and heard a sighing, as if it were in the net-work, and the ruffled surface of the cloth. I then looked round . . . to see if I could in any way assist Mr. Glaisher, but the table of instruments blocked the way, and I could not, with disabled hands, pass beneath. My last hope was in seeking the restorative effects of a warmer stratum of atmosphere. Again I tugged the valve line. . . ."

Coxwell was, all this time, fearful that his companion was dying. But presently, as the balloon dropped, Glaisher came round, and gave first aid to his companion, whose hands had now turned black. Shortly afterwards the descent was made in safety, Glaisher recovering completely from his severe trial. The aeronauts had the satisfaction of knowing that they had made the record altitude ascent, reaching an elevation estimated to be 36,000 feet—nearly seven miles!

This was a magnificent accomplishment, but there is no doubt that both the aeronauts must have been near to death. Nowadays oxygen is usually inhaled after a height of 16,000 feet is reached; while even in lower altitudes the effects on the aeronauts are often severe—the ear-drum having been known to crack at an elevation of 10,000 feet.

As a matter of fact, some years later, on April 15th, 1875, a French aeronaut named Tissandier, with two companions, Sivel and Croce-Spinelli, ascended to a height of 27,950 feet. Tissandier became permanently deaf, while his two fellow travellers were both suffocated. So that it

is not likely that the record made by Coxwell and Glaisher will be easily beaten. Few people would in fact care to attempt to rise to such an altitude.

This great voyage established the fame of the two men, and is better known than any of their further ascents. Nevertheless, they are noted for their observations of atmospheric conditions, and these observations were of considerable importance. An aeronaut in these days—or it would be more correct to say, an airman—ought to be something of a weather expert; and the balloonists made keen observations of the conditions of clouds, electrified strata, rain storms, and so on. But of those mysterious wind effects—"pockets" and so forth, which will be referred to later on—they could tell little.

They learnt that there were different currents, or streams, of air. They could see this by the simple device of tying ribbons down the length of the guide rope, and watching the direction in which they were blown. But their observations were not so interesting to the aeroplane-pilot as to the scientist; and for some little while to come aeroplanes were still to be treated as subject for mere romance, to fill the books of such writers as Jules Verne.

So, in the meanwhile, ballooning continued to flourish. M. Giffard, of whom you have already heard in connection with the early dirigible balloons, built a balloon of mammoth proportions, containing 350,000 cubic feet of pure hydrogen, and lifting 11 tons. This was only used for captive ascents at Ashburnham, and was not a remarkable

success. Glaisher and Coxwell, too, continued to make trips for scientific purposes, often starting from the Crystal Palace. One of their voyages was destined to have a thrilling conclusion.

It was very cloudy, and the balloon, rising to a height of 20,000 feet—these aeronauts were fond of giddy altitudes—drifted over a sea of billowing cloud, which completely hid the earth below. Both men were busy making observations, and the time passed rapidly, until at length it was thought advisable to descend. But on dropping through the cloud reek they discovered that, almost directly below them, the sea lay, leaden and flecked with foam; they were in imminent danger of being drowned. There was not a moment to be lost, and there was but one thing to do. With a shout, Coxwell seized the valve line, literally hanging to it, and the steep descent began. Faster and faster they dropped. At the start they were at an elevation of some 4 miles; but the last 2 miles below the clouds was covered in the space of only two minutes, the balloon crashing to earth at a speed of over 30 miles an hour, wrecking the instruments, and bruising the aeronauts, but lying safely at the very edge of the sea. It was a narrow escape, and Coxwell and Glaisher seemed to be having more than their share of adventures.

Subsequently they made several trips to cloudland solely for the purpose of investigating the formation of those misty mountains, and strata. On one occasion they ascended on a rough midsummer's afternoon, passing through fog banks,

rain showers, strata of dry, cold cloud, snow and hail, and drifting finally out beneath a sky of deep blue, above piled, snowy heaps of cloud, with icicles and crystals of frost sparkling on their balloon, and hanging to every inch of cordage. Photography, however, was not advanced sufficiently at this time to enable them to give anything more than word pictures of the cloud-scapes.

While these ascents were being made in England, it is not to be imagined that French aeronauts were idle. The French were always an imaginative people, and the romance of any scientific work out of the ordinary has always attracted them. This spice of daring and love of romance seems to make them ideal aeronauts, and many balloon voyages of varying interest and importance were made during this period.

In 1867, M. Flammarion made several ascents, and incidentally discovered a new cure for influenza; for it is stated that, when suffering from the malady, he made a lofty ascent and returned to earth completely cured. After this we might dream of an "influenza aeroplane," which in the future will be at the disposal of the hospitals, ready to whirl patients skyward to an immediate and welcome cure!

Flammarion also made several other curious observations. He found butterflies hovering round his car at considerable altitudes. English aeronauts had never observed this phenomenon. Possibly French butterflies, like the French nation, are of a romantic disposition, and fond of blue sky and cloud at lofty elevations! Flammarion,

too, observed opposite wind streams, driving cloud packs in opposing directions—a fact also noted by Glaisher, Green, and other aeronauts. He experimented, too, by throwing a bottle from the car of a travelling balloon, and observing that it did not drop in a vertical line, but travelled obliquely beneath the car of the balloon as it fell, partaking of the balloon's momentum. On another occasion he noticed that the water of the River Marne, which is of a yellow tint, does not mix with that of the green Seine, where the rivers join. From above he could see two rivers, green and yellow, flowing side by side.

About this time a balloon ascent was organized by a French aeronaut in Algiers. Much to his annoyance the natives paid no attention whatever to it, and were not in the least impressed when he soared upwards. It is a curious fact that this same indifference has been noted among the native population in India during recent aeroplane exhibition flights. They paid no great attention to the biplane skimming above them. They seemed to take such a phenomenon for granted, as though they had seen it all before—and the same truth held good in Egypt. Verily, Orientals are deeply mysterious in their ways.

To return to our French balloons, it is interesting to note that, like Flammarion, Tissandier made some curious observations during his ascents. Once when floating high over Calais, he saw in the clouds an inverted reflection of the sea towards the English coast, with ships and steamers crossing it. At another time, when above Paris, he heard

the echoing roar of traffic in the streets below, at one particular elevation, and not at others. A similar phenomenon has been noted by aeronauts in England.

A few years passed, various ascents being made; and then Europe was troubled by the great Franco-Prussian War, and once again the balloon came largely into prominence. It speaks well for Coxwell's ability that the Germans, casting about them for the best aeronaut available, chose him to take charge of their balloon corps, and in a few weeks he was at Cologne, organising the corps, in readiness for action.

As a matter of fact, however, for the purposes of war — reconnaissance or bomb-dropping — scarcely any use whatever was made of balloons during this conflict. Coxwell found difficulty in inflating his fleet, and nothing was done with it. But though the balloon did not appear on the scene for offensive purposes, it was soon doing yeoman service for the besieged inhabitants of Paris, who were unable to break through the cordon of steel drawn round them by the Prussian army.

Before long the great railway stations of the besieged city were being turned into balloon manufactories. It is a romantic picture of history. The great empty stations with the steel lines; the aeronauts cutting and varnishing the cambric envelopes, tarring the netting, furnishing the cars; crowds of starving citizens hurrying with messages to be taken from the city; cages of carrier pigeons; and, in the distance, the stern lines of the Prussians, and the thundering cannon.

The word goes round that Gambetta himself, the French Premier, is to leave Paris by these balloons. He is to escape from the city, organize a fresh army, and march back on a mission of vengeance to rout the besiegers. There is immense enthusiasm displayed at the project. On October 7th, behold the good craft "Armand-Barbes" swaying and rolling in the wind. Gambetta is seated in the car. He waves adieu, and the balloon rises, drifts away, and comes to earth again close to the German outposts, who are at first under the impression that it is one of their own craft from Strasburg. Luck is with Gambetta, for the delay allows him to escape with but a slight wound—and the balloon henceforth is held responsible for the prolongation of the war.

On another occasion we read that Tissandier dropped 10,000 copies of a defiant proclamation over the German lines, and a captive balloon made as many as six ascents a day for the purpose of observing the German lines.

Balloon after balloon was completed and committed to the care of the winds with its precious load of letters, pigeons and passengers. The aeronauts were, as a rule, sailors, and on the whole they proved themselves very efficient, for of sixty-six balloons that floated out of the city during the siege, only five fell into the enemy's hands, and only two were lost, drifting out somewhere to sea. One most remarkable voyage was made by the "Ville d'Orleans," which, leaving Paris on November 21st, sailed northwards for fifteen hours, dropping eventually into the sea close to

Christiania, Norway, after a voyage of about 1,000 miles.

The German artillerymen found it very difficult to estimate the range of these craft, when in mid-air; and, though many of the balloons were shot at, very few were ever in any particular danger from bullet or shell. So that it can be said with truth that in those days Paris owed a good deal to these balloons. They did at least carry the letters safely, and so kept the outside world in touch with the inhabitants of the town, penned up within an impassable ring of swords and rifles.

And now, from this point onwards, I must take my readers swiftly to modern times, not because of any lack of good work on the part of modern aeronauts, but because the balloon had nearly reached its maximum efficiency, and aerial history was fast being made in other directions.

The science of aeronautics was now firmly established in Europe and America. By this time ascents were no longer looked upon as miraculous. A balloon corps was in working order at Aldershot. Every gala had its balloon ascent or parachute demonstration, and the sight of a golden, semi-transparent globe floating over Sydenham became a comparatively common spectacle.

One parachute descent made near Chelsea in 1874 resulted in the death of a Belgian named de Groof. The balloon which took him up had only attained an elevation of some 80 feet when he over-balanced and fell, clutching at his apparatus. In the comparatively short descent the parachute failed to open and de Groof was killed.

There were other accidents, too—one of them occurring in a balloon in charge of Mr. Coxwell, which ascended in Ireland. When descending, Coxwell's passengers became wildly excited, refused to obey instructions and tumbled out anyhow, with the result that one man was left in the car. The balloon was driven by a strong wind seawards, its grapnel dashing into trees and fences below, now catching on rails, now stripping tiles from a farm roof. Twice the balloon was secured by labourers, only to break away again, finally heading straight for the open sea. The solitary passenger, who, all this time, had been unable to escape, gave up hope, but suddenly found that a side current was taking him inland. "The car," he says, "struck the ground, and was dashed along at a fearful rate, knocking down stone fences, and breaking everything it came into contact with in its wild career. . . . I saw a thick hawthorn hedge at some distance below me. It was my only chance. I rushed to the edge of the car and flung myself down on to the hedge!" He escaped practically unhurt, and was lucky in doing so.

A few years later the name of Spencer began to be prominently associated with balloons. Percival Spencer began to make numerous ascents in Bombay, Calcutta, Sumatra, and at Kobé, Japan, meeting with numerous adventures during his career. Following him came Arthur and Stanley Spencer, all splendid workers with parachute or balloon, and all keen aeronauts. It was at Hong Kong that Stanley Spencer met with a quaint mishap, by the way, his balloon being torn by the

long finger-nails of a Chinese helper during inflation. The tear developed into a rent, and the balloon dropped from a height of 6,000 feet, Spencer unfortunately fracturing his leg.

On the Continent, too, ballooning continued to hold the public favour. The military authorities established balloon corps; and England used war balloons in the Bechuanaland campaign. Then came Andrée's ill-fated attempt to reach the North Pole by balloon in 1897. On the afternoon of July 11th he set off from Dane's Island, Sweden, accompanied by Frankel and Svedenborg, in a balloon of 162,000 cubic feet capacity, fitted with a rudder sail, and a very long trail rope. None of the three men was ever seen again and no trace of the balloon has been found. But there remain sundry tragic relics of his voyage, clues to his direction, in the buoys which he let "fall," containing messages as to his progress.

The last of these was buoy 7, and contained the information that it was thrown from the balloon at 10.55 p.m. on July 11th. "All well," said the message. But thenceforward there is no trace of the craft. We can only imagine the fate of the balloon, which had been travelling, at any rate, for a number of hours. It was lost, probably, in a lonely stretch of Northern sea, maybe amid ice-packs, in a frozen, desolate region. It was a rash expedition, and only the boldest men could have faced it unflinchingly.

Then came the Boer War, when balloons were used frequently by the British forces at Ladysmith and other places; and during the Boxer

rebellion in China, British, French and German balloons ascended, mainly for the purpose of survey work.

In 1901, Mr. Frank H. Butler formed the Aero Club of the United Kingdom, and in 1906, Mr. Gordon Bennett offered an international Challenge Cup for a balloon race, to be competed for by any country, the winner being the aeronaut who travelled the farthest distance. The race soon became a popular event in the aeronautical world, and nearly all European countries, and the United States, entered balloons for it from time to time, some noteworthy voyages being made.

Point-to-point races also became popular—these being searching tests of an aeronaut's capability in finding the best air-currents, which would take him from the starting point to the fixed goal—or as near to it as he could get. In 1908, thirty-one balloons took part in a race, starting from Ranelagh, and the spectacle of balloon after balloon bounding skywards, rising until it became a remote coppery globe, and drifting away like a great soap-bubble, was a memorable one.

In 1909, Colonel Schaek, of the Swiss Aero Club, made a magnificent voyage from Berlin, landing in the sea near Norway, after a trip lasting seventy-two hours. The record for distance, however, belongs to Comte de la Vaulx, who, in 1900, voyaged from Paris to Russia in thirty-five hours, travelling 1,193 miles. In 1907, too, Mr. A. E. Gaudron travelled from the Crystal Palace to Brocken, Sweden, a distance of 603 miles, and in 1908 the same aeronaut made a magnificent trip

from the Crystal Palace to Mateki Derevni, Russia, where he was driven down by snow, having traversed a distance of 1,117 miles—this being the longest balloon voyage ever made from England.

In these latter years ballooning became a sport that was widely taken up in Europe, and many ladies made ascents from Ranelagh, among the most enthusiastic being the Hon. Mrs. Assheton Harbord, whose name is well known in aeronautical circles.

But the time was now at hand when the balloon was to be ousted from the first place, which it had held for more than a century. I have tried to show in this chapter something of the way in which the balloon developed, thanks to the pluck and keenness of the pioneer aeronauts. It had risen to an altitude of nearly seven miles; it had supplied sport to many; robbed some of their lives; acted its part in military history; and done splendid work in scientific investigation, being employed frequently, among other things, to take astronomical observers above the cloud pall in order that they might study meteor showers and eclipses. From its car splendid photographs of the misty palaces of cloudland had been obtained, and bird's-eye views of town and country. It had come to close quarters with the thunderstorm, brooded over the battle-field, and run the blockade of a besieged city.

But greater things were to come, for already the petrol-motor engine was a reality; and for many years there had not been wanting those who scoffed at the balloon, because of its helplessness,

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and the slavery in which it was bound by the winds. These scoffers had been experimenting, with a more wonderful goal in view than had been foreseen by the Montgolfiers. And it is to them that I must now take my readers, leaving balloons of the older variety behind, as mere sporting machines, and military "eyes."

CHAPTER V

Flying *v.* Floating

So far I have dealt only with "floating" machines, for with these many aerial enthusiasts were more or less satisfied for a time. For hundreds of years they had been unable to rise above ground at all, and acting, maybe, on the principle that before you can run, you must learn to walk, aeronauts worked the balloon for all it was worth. They were more or less content to float in the air. Even those of them who were most enterprising only devoted themselves to the solving of the problem of steering the balloon, leaving the question of flight severely alone.

Yet, all this time, even when the dirigible was attracting most aerial inventors, there were not wanting men who scorned to be at the absolute mercy of the breeze, and who devoted brains and money to the entrancing problem of flight. And before bringing our history of dirigibles up to date, we must turn back again, and consider these attempts.

First of all, a word about flight in general. In a subsequent chapter I have dealt with some of the particular questions presented by the modern aeroplane in flight.

Few problems have had such an attraction for man as that of the conquering of the air. As

we have seen, people in all ages gave their attention to it. Dreamers, scientists, writers of romance—all have been fascinated by the wonderful freedom of wings, and the possibilities they held. Ballooning, even though it was a remarkable advance, had obvious limitations, and it was not to be supposed that inventors, and those of bolder imagination, would rest content with a drifting globe. Such men, the pioneers of the flight age, strove to overcome the air, rather than to live at its mercy. In their ambition they wanted to rival the birds; and their perseverance is worthy of all praise when we remember that the problems of air were not understood then as they are to-day. First, therefore, we must consider flight from the point of view of these early inventors.

It was obvious that the problem of learning to tread on the air was a difficult one. The balloon or dirigible is supported and has to be propelled. But the flying machine must not only be propelled, but must also support itself. Yet birds and insects managed to do this, and it was notable that all flying things possessed somewhat similar characteristics of structure. Then, said the inventors, the machine, too, must have some of these characteristics.

They also noted one significant fact—the size of the supporting surfaces. In an early edition of the "Encyclopædia Britannica" there is an apt illustration showing the lessons taught by Nature in the different requirements of air, water and land propulsion. There is a bull, provided with tiny extremities for walking on land, although he

himself is a big animal ; there is a smaller turtle, with proportionately larger flappers, for swimming ; and there is a bat with the largest extremities of all, used for beating the air. That lesson was noted by most of the early workers.

Then, too, there was the question of weight. The reason why the balloon rises is really its lack of weight, and it is this very quality that makes it inefficient and unsatisfactory. While, contradictory though it may seem, it is the very weight of the flying aeroplane, which prevents it rising at first, that makes it an efficient machine in the air. Neither feathers nor air-sacs were essential to flight, nor lightness ; and realising this the inventors were encouraged, for it showed them that the flying machine had a chance of success. It had to be the master of the air, and its driving power alone must lift and sustain it.

What, then, was this driving power to be ? As is natural, most of the early workers aimed at copying Nature. A winged car, flapping its way skyward, was their idea of a flying machine, and much of their study and a vast amount of careful observation was expended upon the actions of birds in flight. Even in later years it was often not realised that there were other means of flying than by beating wings.

Yet wings gave men a clue to further developments, for it was found that, instead of beating vertically up and down in simple movements, they developed a complex, screw-like series of motions. About 1869, Professor Pettigrew made minute observations of wing action. He con-

structed a remarkable artificial wing, which, on being operated, twisted and untwisted, and performed wavy lines in the air, almost exactly similar to the lines traced by the wings of a live bird.

But before his day real progress was being made in other directions. In 1768 a man named Paucton described a machine driven by screws, and in 1769 Sir George Cayley, an Englishman, gave a practical illustration of the efficacy of this mode of air-propulsion. The machine with which he did this was a very simple one, but although to all intents it was only a toy, it was the seed from which a great tree grew. It was constructed of corks and whalebone, with feathers for the screws, and was sufficiently powerful to rise from the ground under the action of these light propellers.

Subsequently Cayley wrote very clearly on aeroplane problems, displaying a real knowledge of aerodynamics, and his writings can still be studied with profit. He pointed out that stability may be much aided by setting planes at what is known as a dihedral angle—that is, in the shape of a widely opened V—a plan which is followed in many modern machines. He studied questions relating to pressure-centres, which I shall refer to later on, and demonstrated that the aeroplane would be improved by the addition of a rudder fixed in the same relation to the planes as is a bird's tail to its wings.

Then, in 1809, he built a machine with a surface of 300 square feet in order to test his theories. It was broken accidentally, however, but not before it had shown its steadiness on the ground,

while it is said that, when run forward by a man against the breeze, it would lift him and carry him along for some little distance. There is no doubt that Cayley's pioneer work was conducted in an efficient and workmanlike manner, and was progressing along the right lines. Had he only possessed the power of building a suitable engine, that would be reliable and light, there is reason to believe that he might have flown, for almost every difficulty of the modern airman was recognised by him, in a remarkable manner. His work deserves all honour. It was a splendid advance upon the fantastic ideas which too often swayed unscientific inventors, enchanted with the dream of conquering the air, and in the future, when aviation has fully established its epoch-making importance in the world, his name will be as familiar to the public as that of Marconi, the wireless inventor. At any rate, it is something to know that Great Britain, in those days, led the field in matters pertaining to aviation!

Cayley's work was quickly taken up by others. In 1816 a watchmaker named Deghen built a mechanical flying machine, and Dubochet, in 1834, constructed a flying model with vertical screws, somewhat similar to Cayley's first effort.

It was in 1842, however, that the avalanche of progress began to gather speed. The ball was set a-rolling, and now came Henson, with plans for aviation on a large scale—ambitious plans scarcely warranted by the meagre successes attained up to that time. Henson's machine was never completed, but his plans are of interest.

His aeroplane was a monoplane—single-surface-machine—of quaint, bat-like shape. First and foremost, in the centre was a car, in which passengers, engines and fuel were to be carried. On either side of this, thrown outwards like spread wings, stretched a rectangular frame of stout bamboo, flat and covered with canvas, to form the main plane. It is interesting to note that this was immovable and that Henson had, therefore, disregarded all those writings which insisted that the only method of human flight was by the aid of artificial, beating wings.

Behind the plane, one on either side of the car, were two large fan-wheels, with oblique vanes, rather like the electric airfans which you may see to-day working at any theatre or restaurant. These fans were to act as screws, propelling the machine through the air, and motion was transmitted to them by means of bands attached to wheels on a steam engine, situated in the car. To an axis in the stern, just behind the screws, was attached a triangular tail, in shape something like that of a bird, and this could be contracted or expanded. It was intended to take the place of an elevator, and, by being tilted up or down, was to cause the aeroplane to ascend or descend as required, while for horizontal steering, provision was made in the form of a rudder, fixed just below the tail, and operated by levers from the car.

To facilitate this steering a sail was stretched just in front of the engine, though its exact purpose is not very clear. The planes gave a surface of 4,500 square feet and the tail one of 1,500 square

feet. The machine was to weigh 3,000 lb.—a big weight for the engine, which was only estimated to give some 25 h.p. In starting the machine was to run down a slope, until sufficient speed had been attained to lift it. It will be seen that Henson had many novel and interesting ideas, and once again lack of engine power must be held responsible for the fact that they had no practical outcome.

Henson was quickly followed by Stringfellow, however, who, in 1847, built a flying model which was successful to an encouraging degree. But before he went properly to work after many years of experimenting, he was forestalled in 1867 by Wenham, who, thinking to improve on Henson's work, designed a machine, which he called by the modern name of aeroplane. By dint of careful reasoning and experiment, he pointed out one very notable, and remarkable, fact. This was, roughly, that the actual depth of an aeroplane's surface, from front to back, matters little in comparison with the breadth of the plane in front—with its spread.

To prove this interesting theory, he went to work in a practical manner, building a large model glider, which was of sufficient size and strength to bear a man's weight. Then instead of fixing one plane of large area as the supporting surface, as Henson had done, he cut his material into six narrow "slats," arranging them one above the other, in tiers, like the steps of a ladder, and tilting them slightly upwards. Imagine a gigantic Venetian blind, fixed in a frame, and you will have

some conception of the appearance of the Wenham aeroplane.

The airman was intended to lie beneath the planes, face downwards. Various tests were carried out, the results of all trials being accurately noted. Wenham was encouraged by finding that the quaint machine, so different from the earlier ideas of a flying machine, bore out his theories well, for against a moderate wind it developed a notable lifting power. It was hoped that when the aeroplane was driven forward by screws, or by an engine of some other description, each separate plane would rest on a stratum of undisturbed air, and thus support the aeroplane. But the invention was never fitted with a motor, and its fullest capabilities remained untested.

It is notable that Phillips, to whose important work I shall have to refer again in a subsequent chapter on aerodynamics, also adopted the idea of the superimposed tiers of thin planes, in a rectangular framework. In this case no less than fifty slats were employed, in the form of an open Venetian blind. The framework was mounted upon a wheeled truck, of boat-like shape, and this supported a boiler, and a compound engine, driving a two-bladed propeller at a speed of about 400 revolutions per minute.

The Phillips machine was placed on a circular track of wood like a cycle track, and was attached by long wires to a central post, in order that it might be held in check. The forward wheel was not allowed to leave the ground, no matter what lift should be developed when the machine was

in motion, and in this way free flights were altogether prevented. This was, perhaps, a pity, for had arrangements been made to control the balancing of the machine, a flight might have been successful. As it was, when the aeroplane was in motion, the hind wheels, bearing a considerable weight, rose well clear of the track. The idea of the invention was, however, more to demonstrate questions with regard to planes than to make a free flight.

In 1868—before Phillips—Stringfellow followed in Wenham's footsteps, with a neatly made model aeroplane, combining the idea of the Wenham planes with the driving power of aerial screws. This model was exhibited at the Crystal Palace, and created a great deal of interest. It was somewhat in the form of a triplane of modern days, three planes being disposed, one above the other, in descending order of sizes. It was lightly built and handy, and a particular point of interest was in its engine of one-third horse power, which gained a £100 prize, as, for its small size, it was the most powerful and the lightest little engine ever built, at that time. Stringfellow gave exhibitions with his machine, which the screws drove at a great speed along a stretched wire. He claimed also that it had lifted itself from the ground on several occasions, but at the show it failed to do this. In some ways it is a notable little model, as in shape it foreshadows very accurately the appearance of the modern flying machine. It was built on very sound lines.

I expect many of my readers have visited that

palace of delightful engine models—South Kensington Museum, London. If so they may have noticed in one of the ground floor rooms a gigantic white propeller, and a neatly built model flying machine, distinguished by the number of its rectangular planes. These exhibits are the records of the last experiments that I have to relate in this chapter—those praiseworthy attempts at the solution of the flight problem made by that inventor of guns, and numberless other things, Sir Hiram Maxim.

To him, I think, belongs the honour of building and completing the first full-size, engined aeroplane, intended for actual flight—and a picturesque and imposing-looking machine it was. Picture to yourself a great, bat-like monoplane, with wide-spreading auxiliary supporting surfaces, ranged above a framework, carrying powerful engines. Numerous steel tubes and wires brace and hold the planes in position. The main plane was 50 feet in width, with a depth, from front to back, of 47 feet, and on either side of this were numerous narrower planes, while two rudders, fore and aft, were provided for the steering of the machine. The two engines were compound, each of 180 h.p., driving two propellers, and the whole affair was a great advance on previous machines.

Its sustaining surfaces had an area of no less than 6,000 square feet, and its weight in full flying order, with fuel, water and a crew of three men on board was 8,000 lb.—truly a heavy weight to force through the air when we consider

that to-day Cody's biplane, which is considered to be very heavy, only weighs some 2,000 lb.

But Sir Hiram Maxim had the best hopes of success or, at any rate, of very useful results. Previously to the construction of his aeroplane he had made many models, which gave him various data for the "lift" of the planes, thrust of propellers, and so on; and his flying machine was built along the lines laid down by these experiments. Attempts at free flight were not made, however, as it was deemed advisable to go cautiously at first, while the behaviour of the machine and its powers were tested in safety.

When trials were made with it, it was arranged to run upon a railed track. On one occasion it rose well, breaking an upper rail which was fixed to hold it down, and was undoubtedly flying freely in the air before its inventor, seeing that an accident had occurred, turned off the steam, and brought the plane to earth. The experiments, however, were destined to go no farther at that time, for Sir Hiram Maxim found that they were too costly, and in 1893 he abandoned his large machine—not before he had done most valuable work in the realms of aerodynamics.

But before his final tests were made, new inventors had appeared; and more remarkable work was being done—work conducted on different lines, and leading directly to flight as we know it. In order to deal with this—the work of the gliding machines—we must proceed to another chapter.

CHAPTER VI

Some Further Experiments

UNDOUBTEDLY some of the most important lessons that have contributed to success in flight with machines were contributed to science by a German, Otto Lilienthal, whose name first became known in connection with aerial work in the year 1889. Cayley, Maxim, Stringfellow—these had certainly done a good deal to aid theoretical progress. Their numerous experiments and calculations were exceedingly useful.

But it was Lilienthal's work which opened up a wider track of unexplored country—the country of practical experience. And his work laid down the lines upon which invention ran, until it reached the present-day stage.

Lilienthal was an engineer by profession, and from quite early years his attention had been taken up with the problem of flight, which strongly appealed to him. He guessed that flying machines had a big future before them, and determined to devote his knowledge and his spare time to the construction of some machine which might give to mankind the mastery of the air. In this work he was aided by his brother, Gustav Lilienthal, who shared his opinions.

From the very beginning Otto attached importance to the fact that hitherto most of the work

done by aeronautical inventors had been paper work, and that when machines had been built they were generally finished structures, of considerable size and weight, in which success might or might not lie dormant but which, at any rate, were not the outcome of modest steps from simple to more complex machines. It seemed to Lilienthal, as it may seem to modern aviators, that this mode of work was unsatisfactory.

Ambition is all very well—but it is no use trying to paint an Academy picture before you have learnt to make a simple sketch. You might build your aeroplane, as Maxim did, with the greatest care, and at enormous expense, but both money and time would be wasted if it was afterwards found that it embodied all sorts of unforeseen defects. And to Lilienthal it seemed that the only way in which it was possible to discover what mistakes might be made was to start work in a simple way, before proceeding to build your perfect machine.

With this idea, he devoted himself to the building and management of gliding machines.

A glider is a "gravity-driven aeroplane." It is not provided with engines, and it consists of a number of supporting surfaces so arranged, that, when the machine is started from a slope, it will glide at a varying angle to earth, instead of falling vertically. The place of screw and motor is taken by the force of gravity, which is pulling it earthwards.

On such an aeroplane as this, Lilienthal saw that it would be possible for the human aviator

to learn many valuable lessons, not only with regard to the best shape of plane, but also in relation to the most important problem of balance. He saw that the ability to balance the machine in mid-air, quite apart from any method of driving it, was absolutely indispensable to the aviator. It was useless to construct a splendid aeroplane, and a first-rate engine, if nothing was known of the way it should be balanced in flight, for, at its first launching it would be extremely liable to capsize and smash.

So he decided to content himself with step-by-step progress, and the first secret he tackled was that of balance. He had already made up his mind that curved, or cambered, surfaces were necessary to human flight. If you examine a bird's wing you will see that it presents a concave surface underneath, and it is this shape which is the best for supporting surfaces on an aeroplane. In a later chapter I shall refer to this. Meanwhile, we must note that Lilienthal was already aware of the fact, and his next task was to satisfy himself that man could not fly by the simple expedient of flapping wings.

For this purpose he equipped himself with an outfit of wings, suspended himself by a rope from a pulley, and proceeded to beat the air with exhausting vigour. He did actually raise himself to some little degree, but the conclusion of these experiments left him certain that it was by planes and not by wings that man must learn to conquer the air.

His next step was to make numerous experi-

ments in the sustaining power of surfaces, and from the results he attained in these he began to gather a harvest of valuable truths, of which he made practical use in 1890. It was then that he began his famous and plucky work in actual flight, trusting himself entirely to his simple glider.

This machine was formed of two curved wings, of a peculiar, bat-like appearance, made to fold, and stretched over a framework of bent willow ribs, spread out like the ribs of an umbrella. The outside edges of the wings were flattened to a considerable extent, and the machine was provided with a tail consisting of one vertical and one horizontal plane, the latter being so constructed that any strong pressure from beneath would cause it to give, and rise. The whole affair weighed about 45 lb., and was supported by the aviator, who stood in a space in the centre beneath the two wings, two padded cushions being wedged beneath his armpits for support.

In starting, the aviator leaped into the air from a small eminence, balancing the glider by the motion of his swinging body beneath the wings, and glided successfully to earth. From modest starts he progressed rapidly, until he considered himself sufficiently far advanced to launch his machine from a considerable eminence. He therefore made an artificial hill, in a park near Berlin, and started gliding from a height of some 50 feet. His usual plan was to start running downhill against the wind, which might be blowing at any rate up to twenty miles an hour, until he

was caught and lifted, and found himself floating peacefully along, when he gave all his attention to studying questions of balance and lift, and to the combating of any wayward gusts into which he might be so unfortunate as to float.

The trajectories, or paths, of his flights varied considerably. They were by no means all straight and simple glides. Sometimes he would travel for long distances before coming to earth ; sometimes he would drop at a comparatively steep angle ; and occasionally, he would rise high into the air, attaining a greater altitude than that of the hill from which he had started, and descending in long, wave-like sweeps to earth. For many years he experimented continuously, being wholly taken up with his pursuit, which he found nothing less than delightful. The sensation of gliding fascinated him. Moreover, he was making investigations of the utmost value to future aviators.

In 1895 he decided to adopt a biplane form of machine, which was perfectly successful. The more he glided the more he learnt and the shape of his machine was approaching that of the modern biplane when he met his death during a long glide. He was attempting a soaring flight, when a gust tilted his machine beyond hope of recovery, and he crashed to the ground, dying from the injuries he sustained in the year 1896.

But his splendid pioneer work was already bearing its fruit. In 1895, a young English engineer, Pilcher by name, began to make gliding experiments with a machine very similar

in appearance to that used by Lilienthal. He adopted the system of hanging from his wings, as had Lilienthal, and his glider was of the same bat-like shape. It was more neatly constructed, however, bamboo being used instead of bent willow, and the whole affair mounted on a small *chassis*, bearing spring-hung wheels, intended to reduce the shock of a rough landing. The wings, too, were cambered, their shape being maintained by the aid of a hundred taut wires, which were a considerable source of hindrance, owing to the difficulty of "tuning" them all properly. Two small padded posts supported the aviator, whose hands grasped two bars in the front of the frame.

It is unnecessary to deal with his numerous flights in detail. They were conducted upon the same lines as Lilienthal's had followed, and after splendid work had been done ended, unfortunately, in the same manner. Pilcher was giving a demonstration of his machine's capabilities in a park at Rugby, in 1899, when his wings appeared to collapse, and falling heavily from a considerable height, he was killed. His name is coupled with Lilienthal's and both go down to posterity as pioneers of flight, and martyrs to science.

But meanwhile, across the Atlantic, work had been proceeding steadily, and about the same time that Pilcher began his experiments in England Chanute, one of the most famous workers in the realm of air, was making his name known in America. He was not the only American who was struggling with the problem of flight; but as for the present we are dealing with gliding, and as

Chanute's work was connected with this branch of aviation, before turning to deal with Langley, we must consider Chanute's experiments.

He began his investigations by using a monoplane glider of the Lilienthal type, with a supporting surface of 168 square feet. Going to work in the same way as Lilienthal, and making careful observations, he quickly became a fairly expert glider, making several long trips. He was not satisfied with these, however, finding that the monoplane type of machine seemed to possess rather too steep a gliding angle to make really long flights possible. And, determined to improve his skill, and at the same time to further the art of aviation, he cast about for some other type of machine which would give him better results.

In doing this, he seemed to go rather to extremes, for his next machine, after the monoplane, boasted of no fewer than eight planes, four on either side of the aeronaut, the one above the other. They were all cambered, the rear edges being "frilled" in the bat-like way favoured by Pilcher and Lilienthal.

With this glider, Chanute managed to obtain longer flights, but was not altogether satisfied. He was convinced at length that it was not the best type of machine, and he replaced it by a very successful biplane, with arched surfaces and a tail. In this machine the aviator hung beneath the lower plane, balancing the whole affair, as before, by the swing of his body, and some very long glides were made with it. In structure the biplane glider embodied important features, too,

and it was altogether a great advance on the Lilienthal type, the experiments of Chanute and his fellow-worker, Herring, being of much importance.

As an investigator in the realms of theory, and an earnest worker at the problems presented by the intricate science of aerodynamics, Chanute is well-known, and his work "Progress in Flying Machines" is an aeronautical classic of great value.

It was his experiments and those of Lilienthal that inspired the famous brothers Wright in their pioneer work, which led to a triumphant conclusion—the actual, controlled flight of a motor-driven aeroplane.

It is with their early attempts that we must now deal. From the start the brothers Wright realised that the problem of aviation was a peculiar one, in the solving of which practice of some kind was absolutely necessary. They dealt with the question in a very logical way.

There was Lilienthal making his gliding experiments and observations efficiently, but under considerable disadvantage.

At the most favourable times his observations during any one flight could not extend over a period of any considerable duration. At most he would be able to note all that happened in a glide of a minute or two, and for practical purposes this did not seem to the Wrights to be at all satisfactory. To learn much it was evidently necessary to stay up in the air for long periods, and, in order to make this possible, they decided

to build a machine in which a man could be carried and which could then be flown against a strong breeze, in the manner of a kite. Thus, when it was soaring aloft, or motionless, the aviator could make extended observations regarding the question of balance, which, as I have said, was plainly one of the most important questions in connection with human flight.

After certain necessary calculations had been made, the brothers built a biplane machine, in which the pilot was enabled to lie horizontally. They also tried a special system of twisting or warping the surfaces of the planes to secure balance, and found this exceedingly successful. I shall refer to the invention in a more detailed way in subsequent chapters. After trying the machine as a kite, they began to glide with it, and out on the secluded plains of Kitty Hawk, North Carolina, in the year 1900, they began to draw appreciably nearer to the solution of the problem of human flight.

It was a romantic situation. They were right out in the quietest of country, untroubled by newspaper men or photographers. Keen-eyed, lean and hawk-like men, they were tackling the great question of the century in their own solitude, and throwing down the gauntlet to the air—and they knew that they were making rapid progress. At the end of their first year of experiment they had already established a firm knowledge of several important facts, the first being that practice was the key to human flight. Another important point settled was that steering

up and down could be attained by the use of a rudder, while, as I have said, they found that their system of balancing answered their requirements perfectly.

With these points established, they started their second year's work in a hopeful mood that was splendidly justified. A larger machine accomplished successful glides, and what was more important—for Lilienthal, too, had performed some long journeys—it was found that the paths of the glides could be controlled by the rudder. The biplane could be made to skim the ground, or to rise, as required, while it was still under way. This was a most important and promising point, and marked a great advance upon former experiments.

But the Wrights were by no means satisfied yet. They had the secret almost in their grasp. The problem which had puzzled and fascinated men for so long seemed near to solution in that out of the way corner of the world. Yet with characteristic calm and care the two brothers refrained from rushing their experiments in any way, or from publishing them abroad. They made numbers of calculations, testing every part of their machine thoroughly. The best angles, the best surfaces, the varying pressures—all had to be discovered by very accurate work, and the Wrights did not mean to leave anything to chance. The time was not yet come, they decided, when they should risk the safety of their machine by attempting to drive it with an engine, and so to turn it into a true flying machine.

So, with exemplary patience, in 1902, they built yet another glider, flew it first as a kite and then started to use it for gravity flight, with a passenger. They were now intent upon investigating the question of the soaring motion of a glider, and were every day learning new facts in this connection as they began to see the capabilities of their machine. As a rule their glides were remarkably free from accident, but on one or two occasions falls took place—one, in which Orville Wright came to grief amid a mass of wreckage, being particularly alarming, as the aeroplane, after tilting up steeply, dropped backwards to the ground from a considerable height. The pilot was unhurt, fortunately, and apparently the accident was caused by a momentary confusion about the controls during a moment of rather eccentric behaviour by the machine.

After this innumerable glides were made in varying winds, at all altitudes. Turning began to be attempted, and the brothers found that they were rapidly becoming efficient in the management of their plane in mid-air. They knew that their feats were an advance upon any previously accomplished, and at length they began seriously to consider the possibility of driving their glider by means of a motor engine. Soon after this rumours of wonderful happenings at Kitty Hawk were startling the incredulous world.

But here, for a time, we must leave the Wrights, at the end of their gliding experiments, which led to such splendid results. And before returning to them again, when they made their first public

appearances with their aeroplane, we must deal with some other branches of aerial development.

Before leaving the earlier gliding work, however, it is necessary to consider English progress in this direction. We have a fine exponent of the possibilities of gliding in the person of Mr. José Weiss, whose machines and experiments are well known to members of the Aeronautical Society. Mr. Weiss has taken the form of a bird's wings as the basis of his gliding models, and has had some surprising results with sundry machines. He has experimented with all sizes of glider, indoors and outdoors, and with some of the lead-weighted, outdoor types has succeeded in procuring some wonderful glides of great length. Against a contrary wind, for instance, many of his bird-machines have risen to considerably greater heights than those from which they were launched, and many of the models will travel long distances if launched only from the height of the body, the gliding angle being exceedingly fine. At the time of writing, Mr. Weiss has an aeroplane, built on bird-lines, at Brooklands, of which mention is made later on.

With a full-size, collapsible glider, built on these bird wing lines, a number of experiments were carried out on the breezy Sussex Downs, where a peculiar triangular launching way for models was also erected. This glider was mounted on a stout skid, which took the shock of landing, and for launching movable wings were fitted. It was, as a rule, started from steep slopes, being run forward by three men, one at each wing tip,

and one behind, the pilot being seated between the sweeping planes, which have exactly the appearance of a gull's outstretched pinions.

A gliding speed of about thirty-five miles an hour was attained, and some splendid flights were made, the machine being very steady in the air. On one occasion a distance of nearly half a mile was covered, the glider being in the air for just under a minute—a performance of which any inventor might be proud.

Gliding is now rapidly making its way into favour as a sport. There is a spice of danger in it, certainly. But there is much to recommend it to would-be aviators, who have neither the time nor the money to devote to the true aeroplane —with all the expenses of engine and tutelage which attach to its purchase. The glider can be constructed cheaply, though every care should be taken to see that it is strongly put together and that its supporting surface is of sufficient area. In many parts of England there are gliding clubs in existence, and a glance at the advertisement columns of any of the aeronautical papers will show that there are any number of manufacturers ready to build gliders of all types. A boys' school at Surbiton, to which I shall refer in a subsequent chapter, also possesses a gliding machine built by the boys themselves.

Model gliders are not difficult to make, while for those who wish to pass a few spare minutes on a winter's evening in modest dining-room experiments, gliders of stout cartridge or writing paper can supply amusement. In case some of my readers

should wish to try some indoor aerial competitions —gliding races, or gliding golf, round a course of sundry obstacles, I am including here an account of a few paper machines, that can be made in two minutes, and yet can furnish pleasure and instruction. The difference that extra weight, or the twisting of the planes, will make, for instance, is often surprising, and will give some idea of the care that has to be taken in the building of a real aeroplane.

The first machine is easily made. Describe a semi-circle on stiff paper, with a diameter of about 6 inches. On the diameter describe two arcs, to left and right respectively, springing from the centre of your semi-circle and finishing at either end of the diameter. If you then cut the semi-circle out, and cut along the arcs, you will have a kind of paper swallow, with a very short, pointed tail. Turn the wings slightly upward, and near the front edge of the plane, where the swallow's neck might begin, drop a little pellet of sealing wax. Hold the glider by the tail, pointing slightly downwards, and launch it very gently.

At first it may not be a success ; but by adding to the sealing wax, or putting the weight a little farther forward or back, as may be required, and by slightly altering the curve of the wings, you will soon find your bird glider swooping prettily away from your fingers, sometimes with a peculiar fluttering motion, and sometimes rising and falling in a wave-like path. In calm air these little gliders can be made to fly quite a long distance ere coming to "carpet," and by twisting down

one wing tip they can be made to swoop round in a surprising fashion. They are of no use outside, it should be noted.

Here is another type. Cut out of stout paper a T, the cross top being, say, about 4 inches wide and an inch deep, and the upright about $3\frac{1}{2}$ inches long, and an inch in width. Then roll up the upright tightly for about two inches or more, give the two sides of the cross-piece a slight upward curve, and launch, roll foremost. The roll here acts as the weight, and by rolling or unrolling you can vary your balance to get the best glides.

For a more complicated biplane glider, you will need to cut out from very stiff paper a kind of double T. Make the top cross 14 inches from side to side, and an inch deep, the upright piece 3 inches in length, and at the foot of the upright cut out another cross-piece, 7 inches from side to side. On the longer cross mark off with a pencil a distance of 3 inches at each end, and from that mark again a distance of 1 inch. Turn up the paper at the inside 1-inch mark at each end, and then over at the outside 1-inch mark, nearest the ends of the cross-piece. This will bring your 3-inch flaps across, and form the top bar into a sort of box-kite form. Join the two flaps by sticking paper. With the bottom cross-bar you must do exactly the same, but marking it first into spaces of $1\frac{1}{2}$ inches from each end, with half an inch following each flap. You will thus have a box-kite elevator, exactly half the size of your main biplane behind. The machine will glide prettily, if launched with

the smaller biplane in front, and if weighted properly with a small pellet of sealing-wax.

Other paper machines can be made by cutting out a Blériot or Antoinette monoplane shape, and weighting suitably; and experiment will give many ingenious variations of these indoor aeroplanes.

With this, I must bring the chapter to a close in order to proceed to more important developments. Gliding has done its work in teaching us some of the secrets of flight, and it is questionable whether we should have yet seen serviceable aeroplanes in the air had it not been for the splendid gliding work done by Lilienthal, Chanute and the Wright brothers.

As I shall show, the aeroplane was indeed developing while experimental gliding was in full swing. But it was at the appearance in the field of the Wrights, fresh from the plains and hills of Kitty Hawk that it sprang into such prominence, and became a machine to be reckoned with seriously.

Meanwhile, though aeroplanes and gliders were engaging the attention of so many earnest workers, there were those who looked upon the perfection of the dirigible airship as being more practical than the building of the flying machine. And in order to keep pace with the parallel progress of aviation and aeronautics, I must leave aeroplanes and gliders for a time to deal with airships, pure and simple, before returning exclusively to the heavier than air machine.

CHAPTER VII

The Airship in Being

IN the early part of this book my readers have seen something of the development of the airship idea, and of the attempts that were made to construct a balloon that could defy the wind and carry its pilot to any portion of the compass that he wished. In this chapter I intend to deal with the airship in being, showing how it developed to its present state and efficiency.

The dirigible airship has always seemed to me to be surrounded with a halo of romance, at any rate. But for many people she has been a target for every scornful speech that could be hurled at her, on various grounds. There are two main parties who are interested in aerial subjects—the heavier than air advocates, and the supporters of the lighter than air theory, and it may be that the extreme enthusiasts of both parties are a little biased in their judgments.

Naturally, when balloons themselves were almost novelties, the ability to steer them was considered to be a splendid goal to seek. But no sooner was some advance actually made in that direction by Renard and others, than the heavier than air people stepped forward, and maintained that actual flying machines were the only machines worthy of any serious consideration and that there

were innumerable objections to be urged against the dirigible. Ever since then authorities have not been wanting to support these objections, and it must be confessed that various accidents that have occurred seem to bear out their words.

For instance, Sir Hiram Maxim, the inventor, always a staunch believer in the flying machine, urged various objections against one of the British Army dirigibles, and the points he makes are interesting because they crystallise the arguments of the heavier than air school against the dirigibles. The airship—the "Nulli Secundus"—was 42 feet in diameter, and was driven by engines of 100 h.p., which it was calculated would give her a speed of 40 miles an hour in still air, thus making progress possible against considerable winds. The area of the cross section of the balloon was 1,385 square feet, but the envelope came to a rounded nose at the bow.

Now, Sir Hiram Maxim urged in the columns of *The Times* that if a flat circular disc was erected with an area of 1,385 square feet (42 feet in diameter), and a 40-mile-an-hour wind, representing the speed of the airship, was to blow against it, a pressure of no less than 8 lb. for every square foot of surface would result—or a total pressure of 11,080 lb. In other words, as my readers will understand, it would require a push of 11,080 lb. to drive such a disc forward at 40 miles an hour through still air. Maxim argued that to accomplish this a motor not of 100, but of 1,181 h.p. would be needed, and even when allowances were made for the lessened

resistance caused by the sharpened bow of the dirigible, the h.p. should not be less than 472.

Further points he urged were that the leakage of gas would render airships untrustworthy, that the necessary lightness of structure must make them weak, and that their bulk offered over-great resistance to the air in case of a gale.

The number of men required to manage them, their expense, the great targets they offer for gun-fire, the necessity of providing harbours of large size to accommodate them, their comparatively slow speed and the small altitude they can reach—all these objections have been made to dirigibles, and they are objections which seem to have a good deal behind them. Nevertheless, Governments are still building and improving dirigibles!

It must be confessed, I think, that purely as a spectacle, a great dirigible airship aloft surpasses an aeroplane. The latter, at cloud height, is insignificant—a rattling box-kite, speeding along, and nothing more. But the dirigible—a gigantic shape, like some gold or silver fish—is at once impressive and picturesque as she glides slowly across country, turning quietly this way and that with a slow, almost "sensible" motion. And in war the idea of a great aerial battleship raining bombs from aloft, and leaving a track of fire and death below, is more awe-inspiring than that of the aeroplane scout. But their relative usefulness is undecided.

A number of inventors have devoted their attention to the dirigible in modern times, working out their ideas in various forms and with varying

success. And in the present time we find that the airship has developed into certain standard types, common to different countries, while a few unclassified types exist now, or have been scrapped by their inventors as being unsuccessful. These standard types are the "Zeppelin," the "Astra," the "Parseval," the "Gross," the "Lebaudy," the "Clément-Bayard," and, perhaps, the "Baldwin" and "Zodiac," which, though not so famous as the foregoing ships, are, nevertheless, original types.

The types are distinguished in various ways, but there are three main divisions in which airships can be classed—the rigid, non-rigid, and semi-rigid types. The idea of the rigid balloon was to avoid undue resistance and trouble caused by a flabby envelope by encasing the balloon in an unyielding covering stretched over a metal framework. It was a notable idea—an armoured airship so to speak, although its armour would in no sense protect it against bullets or tree-tops. Schwarz, as we have seen, was the first to adopt the notion, and it was subsequently developed by that prince of airship designers—Count Zeppelin.

The non-rigid type is the direct development of the balloon—an elongated, cigar-shaped envelope of fabric. It was discovered early that the leakage of gas rendered this species of envelope limp, and as a buckled airship covering, forced, may be, against a stiffened breeze, and losing its shape at every mile of progress, would obviously hinder a dirigible and spoil her efficiency, other means had to be sought for keeping it tight. The

method resorted to is that of using an air bladder, or ballonet, inside the envelope. This is a kind of pocket, into which external air can be pumped. Thus, as the gas leaks and the envelope begins to lose its drum-like tightness, the ballonet is inflated, taking up increased space, and reducing the area in which the gas is contained. This naturally extends the outer envelope again, and avoids the "flabbiness," which would be such a serious fault. By compressing the air in the ballonet, too, the weight of the airship is increased—checking undue ascent. This method was the invention of General Meusnier, 1783.

However, it is in the semi-rigid type that many authorities put their faith. In this class of dirigibles the envelope is attached above a rigid metal keel, which, in many cases, is built in sections. The weight of the car and engine is then taken by this rigid keel, avoiding undue strain on the envelope.

From time to time advantages of one system over the others have been urged, and the question of which really is the best for war, or other purposes, is likely to remain under discussion for some considerable period. It may be generally admitted that the principal use of the airship is its employment in war, although, of course, there are others. In this case, its portability for transportation across country with ease is an important quality, and the supporters of the non-rigid type here point to their pet class, and argue that its structure renders deflation and carriage easy. On the other hand, it is weaker than the

semi-rigid dirigible, and it is quite obviously of the greatest importance for a dirigible in war to be safe against destruction by unexpected mishaps.

The semi-rigid dirigible is capable of being transported, even though with greater difficulty than the non-rigid. But the rigid aluminium-framed airship must be able to reach any desired goal by her own power, for it is not to be supposed that the mighty bulk of, say, a "Zeppelin" could be packed away on carts.

In war, also, the question of harbours is of the greatest importance. If a dirigible is not able to ride out a very stiff breeze, or even a gale, she must have some place of shelter within reach where she can wait for better weather. Yet in case of necessity, all but the rigid type can be deflated. The latter must, of course, find a harbour.

My readers will see, therefore, that the dirigible and her uses present many problems which may, or may not, be solved satisfactorily in the future. And the difficulties and expense attending the building and inflation of an airship, too, are considerable. Take one point only—the larger the airship, obviously the greater the probability of her destruction by gales, and the greater the resistance she will offer to the air when sailing aloft. Yet calculations have shown that the larger airship is comparatively a great deal more efficient in lifting power than the smaller craft, and so it is for the designer to choose between two risks—that of destruction in a gale, and that of inefficient power. Nowadays, opinion is in favour of the large airship.

In designing an airship, the chief difficulty that is met with is that of the best distribution of the weight of car and engine, and various problems connected with strain on the framework of the ship have to be solved. To the uninitiated these difficulties are not obvious. It seems a simple matter to make a fish-shaped balloon envelope and suspend a motor engine beneath it. But the arduous work done by inventors, and the fact that, in spite of the progress of engineering and scientific knowledge, the perfect airship is by no means in existence yet, prove that the problem of the dirigible is one requiring the keenest brains to solve.

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Before dealing in detail with the great standard types that I have mentioned, it is necessary to consider certain ships that were built about the years 1898–1905.

One of the names best known in connection with airships at this period is that of M. Santos Dumont. A Brazilian by birth, he interested himself, in his boyhood, with dreams of airships, navigating the air as a ship sails the ocean. The idea appealed strongly to him, and he had a calling for the air, just as men have a desire for the sea, and with this passion burning within him he went to Paris, and before very long was indulging in the pleasures of ballooning. The sport at once captivated him. The spice of excitement it provided—and he had one or two adventures—and the charm of motion far above the earth soon increased the attraction that the air held for him,

and in 1898 he turned his attention to the development of the dirigible airship, having been inspired by the sight of a motor-tricycle, which seemed to him to offer the very form of engine that would make the airship a success.

Beginning in a modest way, he had a small cylindrical balloon constructed, 82½ feet in length, and, in order to avoid weight as much as possible, suspended a tiny car containing an engine of 3½ h.p. directly from wooden rods introduced into the envelope, doing away with the customary netting. A two-bladed propeller was driven by the motor. The airship was a tiny one, quaintly sausage shaped, the car being suspended at a considerable distance beneath the envelope. Steering was attained by a silk-covered rudder, and a trail rope and ballast bags were carried. These two bags were arranged to slide forward or backward as was required, permitting the ship to rise or fall. The trials were encouraging, steering being perfectly well carried out, and the little ship made to perform the usual manœuvres of turning, and also, by means of the sliding-ballast device, dipping or rising at will. The inventor was vastly pleased with his success, feeling, now that he had broken away from the bondage of the drifting balloon, like a captive who had shaken off his fetters. Before six months had passed he was engaged in building a new airship—the "Santos-Dumont No. 2"—of much the same dimensions as those of his first craft. This was destroyed owing to the fact that insufficient provision in the shape of the ballonet was made

to keep the envelope rigid. The weather was rainy and cold on the day of the trial, and this caused the hydrogen to contract to an unusual degree, with the result that the sausage-shaped balloon rapidly became limp, doubled up in a quaint, distorted way in mid-air, and was dashed into some trees—being badly torn—fortunately without injury to the pilot.

Nothing daunted, M. Santos Dumont set to work on "No. 3," having a shorter and thicker envelope with very sharp bow and stern, and of sufficient capacity to enable it to be inflated with coal gas. A long keel of bamboo was suspended immediately beneath this balloon for the purpose of keeping the envelope rigid—an approach to the semi-rigid form of airship—and along this keel the shifting weights slid. This ship was far more successful than her predecessors, and on the day of her trial the inventor turned, twisted, and dived with the greatest confidence over the roofs of Paris, finally circling the gaunt pile of the Eiffel Tower without difficulty.

In 1900 M. Santos Dumont made his appearance again with a new airship—"No. 4," constructed on fresh lines. The bamboo keel now, instead of being suspended above the aeronaut's head, formed a kind of deck, bearing the engine and the bicycle seat, which was fitted for the pilot. The latter was thus, as it were, sitting astride a pole with the machinery of a 7 h.p. motor before him, and the various controls at his hands, while at the fore end of the keel a two-bladed screw revolved. The envelope was of a

shark-like design, and the aeronaut's position did not look especially safe when the ship was in the air. Owing to the weight of keel and engine, pure hydrogen had once again to be resorted to for lifting in preference to the more economical coal gas. After a few experiments, M. Santos Dumont further improved his airship by substituting wire for rope, for suspension purposes, and building a long wooden framework for a keel.

It was about this time that the inventor decided to make an effort to win the Deutsch Prize of 100,000 francs, to be awarded to the first dirigible airship that between May 1st and October 1st, 1900–1904, should journey from St. Cloud round the Eiffel Tower, and return within the time limit of half an hour. It had been offered in 1900, and in August, 1901, M. Santos Dumont set out on "No. 5" to try for the prize. He was destined to have an exciting trip.

He rounded the Tower calmly enough, in nine minutes from the start, and to spectators it seemed that his success was now a foregone conclusion. But suddenly the inventor, seated behind his rattling engine with the wind whistling in his face, noticed that the balloon was becoming deflated. It was limper already than was safe, and a moment's reflection convinced him that one of the automatic valves must be leaking. It was an awkward position, for he could not throw out ballast in order to rise, and far below him, seen dimly through the smoky mist that hovers over a great town, the roofs of Paris were swimming backwards.

There was nothing for it but to go on, and, while the envelope dwindled, the inventor stuck to his post, hoping to clear the town before it was absolutely necessary to descend. But worse was to come, for, when over the outskirts of the city, one of the wires, sagging owing to the limpness of the envelope, was caught by the whirling propeller and cut. Other wires were hanging dangerously near to the flying blades, and M. Santos Dumont, having no desire for a fall from such a height, hastened to stop the engine. Immediately the wind began to drift the airship back towards the Eiffel Tower.

The airship was now in a sorry state, one end flopping and shivering, and the whole craft falling rapidly towards the houses. Down she went, drifted sideways, and cannoned into the roof of a hotel on the Seine Embankment. A flapping of loose envelope, a crash, and she remained caught above the road, draped over the roof, with her inventor clinging to his seat, high above the pavements! He was rescued by firemen, and a few hours later was preparing details of airship "No. 6." In this balloon he gave great importance to the valves!

It happened that just previously in Paris, in May, 1902, another aeronaut, M. Auguste Severo, had been engaged in experiments with a dirigible of a novel design. In this dirigible the motor had been unfortunately placed very close to the envelope, and, probably owing to the inefficiency of the valves, on mounting to a fair height the expanding gas seems to have burst the envelope.

When at an altitude of about twice that of the Eiffel Tower, the airship was seen to burst into flame, and a second later was dropping like a meteor, with horrible rapidity, earthwards. The fall lasted for eight seconds, and both M. Severo and the mechanic, who had accompanied him, were killed instantaneously.

Bearing this and his own mishap in mind, M. Santos Dumont paid great attention to the question of valves in his new airship, and providing it with a 12 h.p. motor, set out to make trials with her. She was fated to be unlucky, for very soon after her launch she collided with a tree, and was badly damaged. She was repaired, however, and in October, 1904, the inventor set out once more for the Eiffel Tower in a great effort to win the Deutsch Prize.

A brisk breeze was blowing against the inventor when he set off, but rising well above the Tower, to avoid the danger of collision when turning, he brought his craft round neatly, went straight ahead, and after a brief moment of anxiety owing to the slowing of his engine, repassed the starting point, well within the time limit. He had won the big prize.

His enthusiasm was still as great as ever, and before long he was at Monte Carlo, making over-sea trips across the Bay of Monaco and along the coast, and testing the strength of sea breezes over the blue water of the Mediterranean. After this airships "No. 9" and "No. 10" were built, the latter being known as the "Omnibus," and being capable of carrying four passengers.

"No. 9" was a particularly novel ship, appealing to the imagination in a delightful way. She was a kind of airship bicycle—a tiny, fish-shaped craft of 7,770 cubic feet capacity, powerful enough to raise her pilot and a 3 h.p. motor, and no more. She was fitted with the usual skeleton keel, and carried a large rudder and a two-bladed propeller in the stern. She was a skiff among airships—a tiny yacht intended solely for pleasure uses, and many fascinating voyages she made. Her inventor would mount in his basket, as a man might mount his bicycle, steer her off, and away she would go, calling, maybe, at various points, that the captain might have lunch or indulge in a chat with one or two friends. On one occasion, starting early in the morning, he sailed gaily up the Avenue de Bois, at the level of the house tops, to the great astonishment of the still sleepy populace, who were startled by hearing a rattling motor outside their windows and seeing the tightly inflated bulk of a dirigible airship sliding past. On reaching a corner, the airship was allowed to descend, and the ingenious pilot entered his house for breakfast, the airship being left outside, as one might leave a cab! Breakfast over, she was piloted away once more, amid cheers. At other times she performed graceful evolutions over the heads of troops, and became a familiar sight to the people of Paris.

And here, for a time, although he built other airships, we must leave the young Brazilian, who had throughout displayed such unquenchable enthusiasm for the sport of air-cruising. We

shall hear of him again in a very little while in connection with other branches of aerial navigation.

In 1903 the inhabitants of London had an opportunity of witnessing the manœuvres of a dirigible balloon above their heads for the first time, when the "Mellin" airship, built by Messrs. Spencer & Sons, made its first appearance. The ship had an envelope of silk, 75 feet in length, with a capacity of 20,000 cubic feet. A keel similar to that used by M. Santos Dumont was suspended by netting from the balloon, holding the car and motor. A tractor screw was situated in the bow, and a large rudder was placed in the stern. The propeller was driven at some 200 revolutions per minute—a slow speed, everything considered. This ship was fairly successful, answering the helm efficiently. She made one journey across London, but was not subsequently developed further.

In 1904 a good deal was heard in England about an airship that was being constructed by Dr. Barton, of Beckenham, at Alexandra Park.

The model of this airship displayed various novel features, and it was confidently hoped that the ship would be able to accomplish a considerable advance in the science of aerial navigation. It was stated, too, that the War Office authorities had their eyes upon the craft, and she was, therefore, an object of considerable public interest, owing to the romance of war that clung to her. She was, for one thing, an advance in size.

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The envelope, which was inflated with hydrogen, was 176 feet in length, having a capacity of 235,000 cubic feet—a considerable advance, say, on M. Santos Dumont's airships, the largest of which, "No. 10," to which I have referred already, having a capacity of only 71,000 cubic feet. It was of a cylindrical shape, with a rounded bow and stern, and the usual ballonet was fitted inside, capable of being inflated or deflated with air at will, and so, as I have explained, keeping the outer skin taut, and counterbalancing the leakage, or shrinking, of hydrogen caused by change of temperature or length of voyage. The outer skin was made of varnished silk.

Beneath the envelope was suspended a long framework of bamboo, carrying a wooden deck, laced in with wire netting, giving it a roomy and safe appearance, as it was enclosed all round. Wire cables were used for the suspension of this "quarterdeck," which was 123 feet in length, and provided with an extraordinary number of bamboo rails and girders, giving it a really nautical look.

Propulsion was given by means of four propellers, two at either end of the ship. These were driven by two 50 h.p. Buchet motors, bolted by aluminium castings, which rested on thick bamboo rods. Two hundred revolutions per minute were developed by the propellers, the power being transmitted to the shaft by means of belts and gearing. Altogether the deck, with motors, wires, and girders, presented a crowded and not over-light appearance, and further room in the model was

taken up by no less than thirty narrow aeroplanes, ranged in horizontal tiers and pivoted for the purpose of aiding vertical steering. Subsequently the number of planes was lessened, however, the ship losing some of her picturesqueness in the process.

The novelty which attracted most attention, however, lay in the system of balancing the vessel and keeping her on an even keel when in the air. At either end of the keel were two large tanks filled with water, and connected with each other by a pipe. In the centre of the pipe-length was a pump, by the aid of which either tank could be filled at the expense of the other, thus increasing the weight at one end and lessening it at the other.

By this means the ship could be steadied, and any undue tendency to dive or tilt could be instantly controlled. On the whole, the ship was undoubtedly original in construction, but she was handicapped from the first by the cumbersome weight of her deck, which was not built upon the lightest possible lines. Her trials were carried out with some success, but eventually she was unable to return to her starting point, and was injured in landing. Further experiments were more favourable, but the War Office apparently did not think the craft promising enough to justify her adoption in the Army. At any rate, she dropped out of public notice, which was unfortunate, as she might, with alteration, have turned out to be an improvement on other navigable balloons.

Count de la Vaulx, the enthusiastic French aeronaut, who made many good balloon trips, was another worker at the problem of the dirigible about this time. His ship did not present any particularly novel features. The envelope was cigar-shaped, and below it was suspended a beam, from which again was hung the small car containing the motor. Propeller and rudder were situated at either end of the rod, power being transmitted from motor to shaft above by a rod and bevel gearing and the rudder controlled by wires from the car. In 1906 and subsequently some successful voyages were made to and from various points, but the airship was not developed further.

So far, as my readers will see, I have dealt only with "odd" airships—craft which, when once constructed, were not destined to be taken up and developed upon any further lines. Of those I have mentioned Santos-Dumont's fleet were undoubtedly the most successful, and to him all praise is due for the determination he displayed and the spirit which led him to prepare the plans of a new ship almost as soon as its predecessor had come to grief.

But it now becomes necessary to leave these varying ships in order to consider the great standard types, which have advanced the dirigible in public favour, and have attained a size utterly dwarfing the largest of those ships of which I have so far treated. I believe that the word "airship" nowadays conjures up in the mind one particular type of craft in preference to all others—

and that type is the famous "Zeppelin." To her I will, therefore, first devote attention.

It was the Schwarz rigid airship which first guided Count Zeppelin's thoughts in the direction of aerial navigation. It was in 1897 that this vessel made its public appearance, and it was shortly before this date that the Count began to take an active interest in aeronautics. Despite the accident which befell it, the Schwarz dirigible seemed to him to be built upon promising lines, and before long he was turning his attention to the design of a colossal ship.

From the first it had seemed to him that the only type of airship which stood any chance of success was the rigid type—that is to say, an airship which, no matter whether it is deprived of gas or not, keeps its shape, and can, therefore, always present a perfectly taut surface to the air. Schwarz's craft had an envelope of aluminium, but it was not Count Zeppelin's intention to follow this inventor's lines altogether. He was a practical man, blessed with means and a strong imagination; and for this reason he was not only able to conceive the idea of the "Zeppelin"—a bold conception compared with the tiny craft that had preceded her—but also to carry it out. Nevertheless, the funds required for the building of his invention were very considerable, and he therefore proceeded to form a company to interest itself in the balloon, and fortunately was successful in receiving influential support.

It was obvious that an airship, as expensive as this projected craft was to be, ought not to be

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exposed to any unnecessary danger until its strength and capabilities were fully tested. The Count, therefore, decided, in order that shocks of landing might be avoided, to build his great craft on water, and for this purpose erected a great "dock" on Lake Constance, at Manzell, near Friedrichshafen. From an article by Mr. Thomas E. Curtis, in a number of the *Strand Magazine*, some years back, I take the liberty of quoting the following description of this novel airship-house:

"Four hundred and fifty feet long, 78 broad, and 66 high, it is, indeed, a formidable object. The rear end, through which we are able to see part of the airship, is usually covered with a curtain to ward off the curious; and the front end is given up to offices, store-rooms, and sleeping accommodation for such workmen as have to act as sentinels at night. There can be little doubt that this construction shed is one of the most perfect of its kind ever devised, and, incidentally, it shows the care and skill with which Count Zeppelin and his engineers prepared themselves against untoward delay and accident in the consummation of their great plan. If, for instance, we could row up to this immense floating structure, we should find it resting gracefully upon 95 pontoons, and we could understand the advantage which such a shed, floating upon the bosom of an open lake, would have for the inventor in the experimental trials of his machine. No ground to fall upon, and nothing to run against! Again, by unanchoring

his shed at one point only the inventor allows it to turn, as on a pivot, with the wind, and thus gains the aid of the wind in getting the balloon out of the shed with the minimum of damage and the maximum of speed.

"The construction of the building in which the balloon was housed alone exceeded 200,000 marks. . . . If we examine closely we discover that part only of the pontoons support the shed, and that the remainder support the balloon. In other words, the balloon, on its own supports, can be easily moved in and out of the shed."

It will be seen from the above description that no pains were spared to assure the construction and the subsequent trials being carried out successfully and without accident. Out there on Lake Constance this quaint shed floated, kept stationary by four gigantic anchors lent by the dockyard authorities at Kiel. And in it there grew the most astonishing aircraft that the world had so far seen.

Probably my readers are not unacquainted with the appearance of the "Zeppelin." This cigar-like structure is described well and fully in the article which I have just quoted:

"Conical at both ends, in order that resistance to the air may be lessened, and cylindrical in shape, it measures 390 feet in length, and has a diameter of about 39 feet. It looks, even at a close view, like a single balloon; but in reality it consists of seventeen small balloons, because it is divided into seventeen sections, each gas-tight, like the water-tight compartments on board a steam-

ship. The interior is a massive framework of aluminium rods, stretching from one end of the balloon to the other, and held in place by seventeen polygonal rings, arranged 24 feet apart. Each ring is supported by aluminium wires, and the whole interior, looked at from one end, appears as if a lot of bicycle wheels had been placed side by side. The whole series of seventeen sections is covered with a tough and light network of ramie.

"Each section, as we have said, is a balloon in itself, and each section is covered with a light silk texture which, by virtue of an india-rubber coating, is, in the general sense of the word, gas-tight. So tight, indeed, has each balloon been made that one filling of hydrogen (the lightest and most volatile of gases) has been proved to last for two or three weeks.

"The exterior of the balloon is made of pegamoid, which protects it from both sun and rain. The total capacity of the interior balloons is about 12,000 cubic metres of hydrogen gas (roughly 420,000 cubic feet); and, lest any of our readers should bankrupt himself by attempting to construct a Zeppelin balloon, we may as well add that each filling costs in the neighbourhood of £500. When the balloon is ready to be filled, the hydrogen gas, in 2,200 iron bottles, is brought alongside the balloon shed on pontoons, each containing 130 bottles, and all connected with each other, thus forming a single reservoir, which in turn is connected with the balloon by a distributing pipe. It takes five hours to fill the whole balloon.

"It is one thing to build a balloon and another

to make it go. It is still another thing to be able to control its flight, steering it this way and that with the wind against it. . . . But it is in these very respects that Count Zeppelin may well be said to have been successful. . . . The propulsion of the balloon under consideration is effected by four screws made of aluminium, all working as do the propellers of a ship. Two of these screws are situated about a third of the total length from the bow, and the other two a like distance from the stern. Each screw makes over a thousand revolutions a minute."

My readers will see well enough from this description that the construction of such a balloon as this was no matter to be undertaken lightly, and that the destruction of the monster was likely to prove expensive.

Two cars were swung below the envelope, under each pair of screws, which revolved on either side of the ship, and these were connected by an aluminium keel, of lattice-work and plates. Each car contained a 16 h.p. motor, driving the propellers—it is notable that the propellers were reversible, thus being able to drive the airship either backwards or forwards, as might be required. There was a further novel provision for the purpose of tilting the balloon, thus giving it vertical steering. Mr. Curtis says:

"One very notable feature of the latest airship is the sliding weight—made of lead and weighing 300 kilos—by means of which the balloon is raised or lowered at the bow or stern. The weight was secured in the centre of a dragging

cable, the ends of which were fastened fore and aft. As the dragging cable was about 328 feet long, with a slack of about 75½ feet, the stability of the vessel was greatly improved. The heavy, deep-hanging weight acted as a regulator of the pendulum-like motion of the airship. In order to provide for a descent into the water the sliding weight is enclosed in a water-tight box filled with air, which causes the box to float when it touches the water. . . . One more word and we are done with the technical construction of the balloon. The steering apparatus consists of rudders placed at the bow and stern of the balloon, and controlled by wires attached to the two cars. Each rudder is made of cloth with a framework of aluminium."

The cars, it may be added, were also in communication with each other by telephone.

Such was the great "Zeppelin No. 1," to which I have devoted considerable attention, as her sisters were built on much the same lines, so that she stands as the representative of the standard Zeppelin type. She was a fine creation, and as wonderful an advance upon all previous types as the "Dreadnought" was upon the older battleships in the Navy. Her construction had been watched with the greatest interest by the German Government, and the Kaiser himself paid a great deal of attention to the ship. It was thought, probably, that if successful she might prove of the greatest value as a war machine, and a great gathering assembled to see her trials on July 2nd, 1900.

She was drawn out on her raft, and the word to let go having been given, she rose easily, and, to the steady throbbing of the engines, began to sail forward against an easterly wind. A turn of the rudder, and round she swung, then back again to her course, and onward, progressing with sundry manœuvres for a distance of three and a quarter miles. Then an accident occurred, preventing further movement of the balancing weight, and one of the steering lines became entangled.

"The accident to the running weight," says Mr. Curtis, "made it necessary to avert the imminent danger of capsizing by stopping and going astern with the screws." Count Zeppelin himself said that henceforth the whole voyage consisted of alternately going ahead, and then astern, with the screws, so as to prevent an excessive inclination.

Finally, however, the great craft was safely brought to the surface of the lake, having carried out her preliminary manœuvres with very encouraging success. But so far, the airship was not as perfect as her inventor desired to see her, and he began to work on another craft, which was finished in 1905. The motors in this ship gave 85 h.p., and special linen-covered planes were placed at both ends of the envelope as an aid to steering—both vertical and horizontal. Trials with this ship were equally satisfactory, taking place, as before, over the lake, upon which she could "land" without fear of damage. "Zeppelin 3" was then built, and with sundry alterations and improvements did considerably

better than her sisters, but, like them, was eventually put aside to make way for No. 4, which was the first of the airships of this type to have the covered keel attached to the under side of the envelope, with the two cars swinging in gaps just below it. These cars were of aluminium and steel tubing, and were built in boat-like form, being connected by a gangway. They were 26 feet in length, and in order to avoid damage by landing were provided with pneumatic shock absorbers of special design. Powerful Daimler motors drove the propellers.

Fresh points in the later Zeppelins were as follows : A long petrol tank was attached beneath the envelope just forward of the front car, thus ensuring a good supply of fuel for long runs ; the outer envelope was of rubber cloth, and at stern and bow, groups of small elevation planes were fitted. In the stern two horizontal planes projected on either side of the ship, in order to preserve the equilibrium. The ship now presented a very business-like appearance. You can picture her, a great yellowish-grey shape, throbbing steadily along, swinging her bulk this way and that as the helm is put over, with a serene and majestic motion only equalled by that of a great warship, ploughing her way through the sea. It is no wonder that all Germany became immensely enthusiastic over Count Zeppelin's work. And it was for this reason that such ready sympathy was shown him after the ill-fated voyage of No. 4, which ended in its destruction.

This voyage was made in the summer of 1908. Just previously she had made a fine voyage to Lucerne and Zurich, for over 230 miles, and in August, Count Zeppelin decided to take her out for a 24-hour flight. She was to be taken over by the Government if this voyage was successful, and the crew started off in great hope that their trip would show the world the superiority of the "Zeppelin" over all other forms of aerial cruisers.

The journey passed without incident for a time, the ship holding steadily to her course along the Rhine as far as Mainz. So far the speed had averaged 24 miles an hour. But now it dropped to 12 miles an hour as she swung round and headed back for Lake Constance. When she had travelled no less than 370 miles, she was forced to land at Echterdingen, near Stuttgart, owing to temporary engine trouble. She had then been actually in the air for over 20 hours.

But while at Stuttgart, ominous weather signs were noted. Clouds were sweeping up, obscuring the sky, and it was rapidly becoming dull. A breeze that quickly increased to a gale sprang up, accompanied by a heavy thunderstorm. And then it was that the disadvantage of the rigid type of airship was clearly proved. Unable to reduce the bulk of the craft by deflation, the men around her tried to make her fast. But she broke away, leaped up, and a moment later, to the accompaniment of a sharp explosion, burst into flame. It has been said that she was struck by lightning. But another

suggestion is that an electric spark caused by a discharge from a wet trail rope set fire to the petrol vapour. Be that as it may, the envelope ignited, and she crashed down to earth, a blazing, crumpled ruin, after a most auspicious trip. It was an instance of "real bad luck," and Count Zeppelin was overwhelmed with grief.

But the fine voyage made a firm foundation upon which Germans could rest their faith in the type of dirigible, and by October a fund of no less than £300,000 had been publicly subscribed for the construction of a further series of ships.

In 1909, "Zeppelins" 2 and 3 made various trips. Count Zeppelin journeyed to Berlin in his ship to meet the Kaiser, in August, after a triumphant voyage. The return journey was an exciting one, for, owing to an injury to an envelope, caused by a broken propeller blade, the ship was landed in a high wind. The force of the wind increased and the ship looked like breaking away, once again showing the disadvantage of the rigid type of ship. Soldiers were hastened up, clinging to the keel, swung this way and that, now lifted, now dropped, as the great hull rolled and pitched. But they clung to their posts well, and at length the weather moderated and the vessel was saved.

Another famous Zeppelin type ship was the passenger vessel "Deutschland." She was employed in the first attempt to put the dirigible airship to really practical use by instituting a regular passenger service aboard her, and in the summer of 1910 she made a good voyage of over 300 miles with her crew. Subsequently, with a

crew of twelve and a score of passengers, she made her maiden "public" trip. But once again the disadvantage of the rigid dirigible airship was destined to be illustrated, for, on the 28th of June, when the ship was proceeding overland with her passenger load, she ran into a blustering wind, and became unmanageable, owing to propeller trouble developing. Unable to make headway, she was at the mercy of the wind, and was finally swept into a wood, torn, crumpled and wrecked.

It is a proof of the great faith placed in Count Zeppelin's invention, however, that at the time of writing there are three more Zeppelin airships under construction—one being destined, it is said, for Polar exploration. It may be that the romance attached to these mighty craft has overweighed the judgment of the authorities—though that is unlikely. Perhaps, with vastly greater engine power, it is hoped that the rigid ship will be able to ride out any gale that may be encountered. But if a fifty or sixty mile an hour wind were met, it would require a very efficient ship to combat the resistance that would be set up by its bulk, more especially as the paper-speeds of airships are generally too high, it being found in practice that the dirigible can rarely obtain the theoretical speed which is assigned to her when building.

Even if the rigid airship were ever perfected, it is difficult to believe that she could be of very much use, for reasons which my readers may appreciate after reading farther in this book. The German Government, however, is evidently un-

convinced. In a recent novel, written by Mr. H. G. Wells—"The War in the Air"—a fine picture is drawn of a great airship-park, where hundreds of mighty dirigibles are constructed, as ships are built in Portsmouth Harbour. It is curious to note that at Friedrichshafen, at the present minute, something of the same sort is developing. For there, at the home of the "Zeppelin," wharves and docks are being built, and hydrogen manufactories and an aluminium foundry are busy aiding the making of the ships. And some French writers have already had visions of a grey battle-fleet sailing out from Germany to menace their frontier.

Faith in the rigid type of ship, however, is not confined to Germany. At the time of writing a great British Naval airship is almost completed, and this, too, is of Zeppelin type. By the time these lines appear in print she will probably have issued from her dock and made her trials. But, in the meantime, it is only possible for me to give a description of her, without any reference to her behaviour in the air.

This ship is of colossal size, a "Dreadnought" or "Orion" among airships. Her total length from stern to bow is no less than 512 feet, and she is 48 feet in diameter, while the capacity of her great envelope amounts to, roughly, 700,000 cubic feet. The comparison between this craft and, say, Santos-Dumont's little No. 9, capacity 7,770 cubic feet, is laughable! She is in the form of a decagon, with ten longitudinal girders built up to form her sides. She is of a whale-like shape,

more bluff at the bow than the stern, and the metal used in her construction is a special magnesium alloy of aluminium, known as duralium, which is about two-and-a-half times as heavy as water, and is very tough, giving a breaking strain of 22 tons per square inch.

Within her outer envelope are a number of gas compartments—eighteen or twenty—covered with special fabric, and divided by netting, while underneath the outer envelope is a long keel, floored with spruce grating, and covered in, forming a gangway by which it is possible to pass from car to car. There are two cars, or gondolas, in stern and bow, respectively, made of timber, and of rather novel shape. Each of the gondolas contains a Wolseley motor of high power—over 100 h.p.—and there are three propellers, two driven by the engine in the forward car, and one by that in the stern car, all giving 500 revolutions per minute.

Near the stern of the envelope are two large horizontal fins, to steady the ship, and at the bow are two triplanes, to aid in vertical steering, while for the same purpose two biplanes, one on each side of the envelope, are situated in the stern. For horizontal steering, vertical rudders are placed at the stern. Her picturesque appearance in the air will be greatly enhanced by the novel system of colouring which is adopted. The upper half of her envelope is specially dusted with aluminium, the lower part being bright yellow. The resulting spectacle when she glides out into sunlight, with white planes, envelope glittering in the

rays, and the propellers turning so rapidly that they resemble solid discs of flashing metal, should be a magnificent one. It is only to be hoped that she will not share the fate of so many of the German ships, and prove to be a monument of wasted skill and money.

The "Schütte" rigid is building in Germany —a smaller vessel than the British Naval craft.

Another rigid ship which is at present under construction is the Austrian "Wallach von Hallborn," for military purposes, of which little of importance is known. France has hitherto paid small attention to Zeppelins, but she has the Spiers rigid ship building, a 14-sided ship with steel framework, driven by four propellers, and very much after the fashion of a small "Zeppelin." Such is the rigid airship, and England and Germany seem to be the only nations who are taking it very seriously, although there is a rumour that a rigid airship of novel design is to be built in America. Whether this is true or not remains to be seen.

Leaving the rigid ship, we must now turn to the semi-rigid type. The following names instantly recur to the mind—Lebaudy, Gross, Siemens-Schukert, and Wellman.

Of these the most famous, and as many people believe the most efficient of all airships, is the "Lebaudy." I have already explained that the semi-rigid type possesses a rigid keel, to take the weight of car and engines. But as the "Lebaudy" is a vessel of considerable interest, I intend to give a more detailed description of one of the later

types. Meanwhile, I will refer to some of the earlier vessels of the Lebaudy type. The ship first made her appearance in 1902, and attracted public interest by her design. She was bright yellow in colour, and her envelope came to a sharp, shark-like bow, the stern or "tail" being gently rounded, and provided with quaint vertical and horizontal fins, suggesting the feathers of an arrow. The envelope was attached to a rigid floor of steel tubes, from which was suspended the car. Some most encouraging results were obtained with this ship, and the attention of military authorities was quickly attracted to her, and to the ships which followed her. Finally, M. Lebaudy presented the French War Department with the 1905 ship, and immediately the department began to build another of the same type, which was named "La Patrie." I shall not describe her in detail. Suffice it to say that in November, 1907, during a voyage, her motor broke down. She was brought to land and anchored, but, ere twenty-four hours had passed, was torn from her moorings by a boisterous wind, despite all the attempts of a company of infantry to hold her. Try as they would, they were dragged along the ground, while cables broke and posts were uprooted. Then the ship tilted and some of her ballast went by the board, lightening her still further. A moment later the empty ship was leaping upwards into a darkening sky, and she vanished from sight, sweeping westwards, towards England.

She was subsequently sighted in Ireland.

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But thence she drifted seawards, and the rest of her history can be filled in by imagination. It is fortunate that none of the soldiers was carried with her. At present the French Government is building various semi-rigid machines, and has one or two in commission. So far I have omitted to give a detailed description of these interesting ships.

By the courtesy of the editor of the *Morning Post* I am enabled to quote two articles which appeared in the pages of that journal concerning the British Lebaudy ship, which, I think, must be naturally of more interest to my readers than the ships of a foreign nation. This airship was purchased from M. Lebaudy by the readers of the *Morning Post* in 1910, who contributed lavishly to a National Airship Fund organised in a patriotic spirit by the newspaper. Subsequently, after a very fine voyage, of which I am enabled by the editor to quote a description, the Lebaudy was handed over to the Government, and was for a time housed at Aldershot. However, a most unfortunate accident was destined to mar the career of the original ship in England, for in the beginning of May, 1911, she met with a serious accident. She was proceeding to her harbour at Farnborough, after a successful trial trip, when a side gust forced her out of her course, and swept her against a house over which the torn envelope promptly collapsed. The heavy car came into contact with a number of trees, snapping four of them cleanly at the lower parts of the trunks, but the seven passengers who were on board at the time were fortunately unhurt.

At the time of writing the possibility of the airship's repair is said to be a matter for doubt, and it may be that she will be struck off the active list of the British Air Fleet. I am quoting the following particulars of the ship, however, from the *Morning Post*, as they are more or less applicable to the Lebaudy type generally, and will give my readers a complete idea of the modern semi-rigid dirigible airship:

"The envelope is 103 metres (337 feet 10 inches) in length, 12·2 metres (39 feet 5½ inches) in diameter, and has a cubic capacity of 10,000 metres (353,165·8 cubic feet). In the bows it tapers to a sharp point, and is egg-shaped at the stern. It is composed of panels of waterproof canvas, consisting of two tissues of cotton and two layers of vulcanised india-rubber, superposed alternately, these panels being glued and sewn together. The outer tissue is dyed a non-actinic yellow to diminish the injurious effects of light on the rubber, while the interior layer of rubber makes the envelope more gas-proof, and preserves the cotton tissue from the injurious effects that might be caused by impurities in the gas.

"The gas-bag is filled with hydrogen gas, the purest and lightest obtainable, with a lifting force of 1,175 grammes to the cubic metre; in other words, 100 feet of gas lift between 7·33 and 7·34 lb. Thanks to the care with which it is constructed, it loses considerably less than 1 per cent. of its volume in gas every twenty-four hours. The envelope is provided in its lower surface with two valves of large diameter, which allow of the

evacuation of hydrogen, more particularly while the balloon is in flight. These valves are automatic; that is to say, they open as soon as the pressure of the gas in the envelope becomes excessive. Further, they can be worked by hand. There is, in addition, a valve at the top of the gas-bag, which is usually closed by a diaphragm. This valve can only be worked by hand, and allows the balloon to be entirely emptied. The two lower valves are placed in the stern of the gas-bag to avoid all risk of ignition from the motors. In cases of emergency two long ripping panels, one fore, one aft, glued and only lightly sewn to the rest of the fabric, allow the balloon to be completely deflated in a few seconds. By means of four observation holes, each covered with glass and framed with aluminium, the condition of the interior of the balloon can be inspected visually when it is at rest in its shed. Water and metal manometers show the pressure of the gas in the envelope at any given moment.

"There are inside the gas-bag three ballonets that can be filled with air under pressure, so that when the gas contracts or is lost the pressure within the envelope, which preserves the shape and rigidity of the gas-bag, may be maintained. These ballonets have a capacity of over 2,500 cubic metres, or rather more than a quarter of the capacity of the balloon. Their size is an important factor in enabling the airship to travel at a height of from 6,000 to 6,500 feet, an altitude at which it would be far beyond the range of an enemy's fire. The ballonets fore and aft of the

central one have an additional purpose. By forcing air into one or other of them the pilot can change or regulate the longitudinal equilibrium of the airship so as to make it fly point upwards or downwards at a certain angle, as he wishes. Each ballonet is provided with a safety-valve, which opens automatically and allows the air to escape at a pressure slightly inferior to that of the gas. When need arises these valves can be worked by hand.

"The air required for the ballonets is pumped into them by two powerful centrifugal fans which can work either separately or together, and are each of them driven by a separate motor, so that in case one engine breaks down it will still be possible to use the other ventilator. The air is forced by the ventilators into a collector, whence it is admitted into any of the three ballonets that the pilot desires. In the very exceptional case of all three ballonets being filled before the end of the flight—that is, if loss of gas and contraction should reduce the volume of the hydrogen in the gas-bag by more than a quarter—air can be pumped directly into the gas-bag, so that under no circumstances need it lose that rigidity which is indispensable to a dirigible balloon. . . .

"The movable planes, which are intended to steer the airship both horizontally and vertically, consist of—

"(1) A vertical plane articulated round an almost vertical axis. The word 'almost' is used advisedly, since in case of accident the rudder falls into a neutral position in wholly automatic

fashion. This is the rudder in the ordinary sense of the word. It is placed immediately below the gas-bag at the stern of the rigid under-frame, which transmits its action directly to the dirigible.

"(2) Two horizontal planes with rounded angles, articulated round the same horizontal axis, which is fitted to the under-frame below the centre of the balloon. By deflecting these planes the pilot can make the airship rise in a direction parallel to itself without throwing out ballast, and he can in the same way make it descend. . . .

"The fixed planes, which, like the movable planes, are built of steel tubes with canvas stretched over them, are both horizontal and vertical, and are arranged as follows:

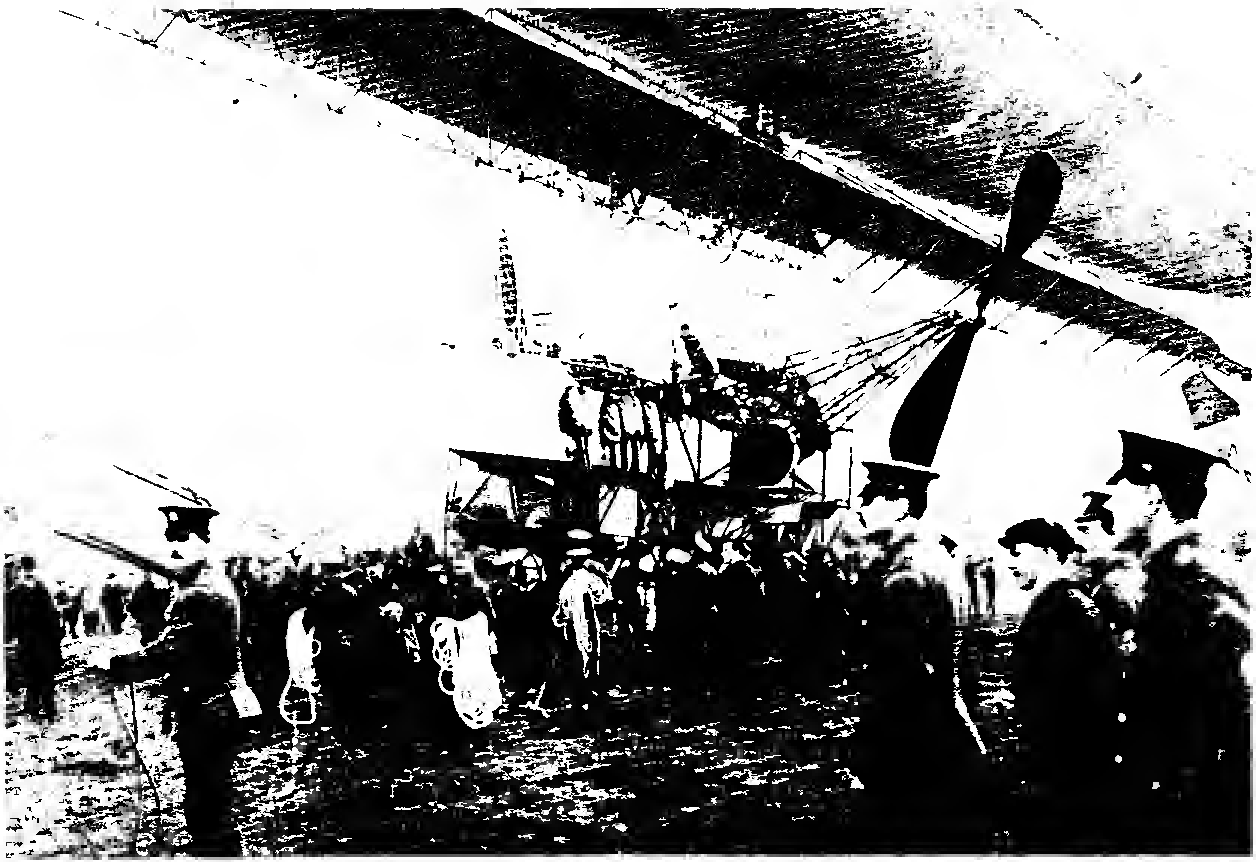
"(1) The tail fins (the *papillons* or *empennage*), vertical and horizontal planes, shaped rather like the wings of a butterfly and fitted along the axes of the egg-shaped stern of the gas-bag. These fins prevent the airship from rocking and pitching or going forward in zig-zag fashion under the forward thrusting pressure of its engines.

"(2) The rigid girder-built under-frame immediately beneath the gas-bag consisting of three articulated parts: the forepart, which is small, angular, and covered with canvas in the horizontal plane; the central longest portion (80 metres or 262 feet in length), rather narrow (3 metres or 9 feet 10 inches in breadth), 2 metres or 6 feet 6¾ inches in height, covered with canvas for its whole length in the horizontal plane, whereas vertically only the stern half is canvas-covered;

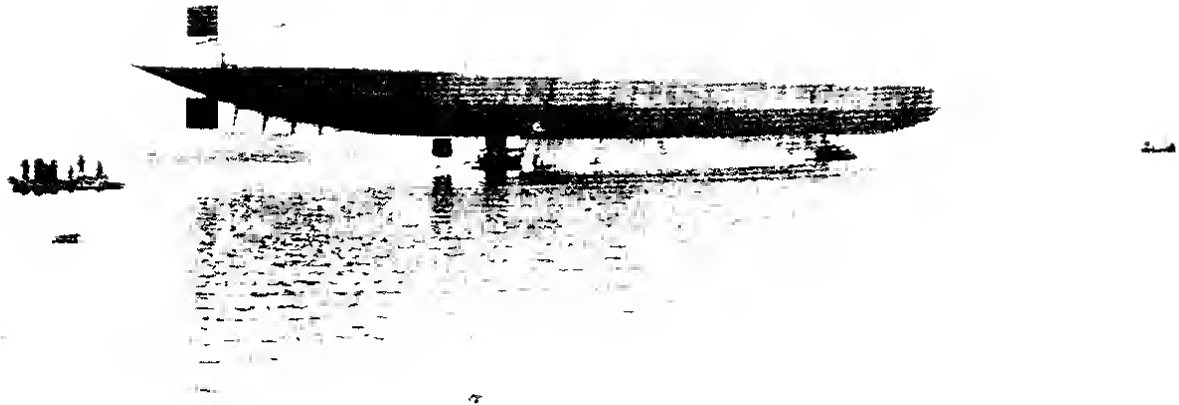
and finally the tail piece, which is cruciform and shaped like the feathers of an arrow, canvas-covered both horizontally and vertically, and ending in the rudder. The articulated bow and stern extremities can only be adjusted with the balloon at rest and are fixed during flight.

"This combination of planes ensures the horizontal and vertical stability of the balloon when it is under way. With the further aid of the horizontal rudders and the three ballonets the pilot is enabled to make the airship rise or descend by inclining it at an angle and making it glide along on the same principle as an aeroplane with a very large area, both the upper and lower surfaces pressing against the air. In the earlier airships of this type only the lower surface of the under-frame could come into action, as the under-frame was fixed immediately to the envelope and there was no free air space between them. The fire-proofed canvas of the under-frame protects the envelope and the gas within it from all danger of combustion from the motors.

"The under-frame is provided with rings and hand ropes, and a whole collection of steel cables called the *chevelure*, which, fastened as they are so near the gas-bag, allow the balloon to be easily manœuvred when it is on the ground, and if need be firmly anchored. It is obvious that the unwieldy gas-bag can only be imperfectly controlled when the airship is on the ground, unless the ropes which hold it firm are fastened to a point at no great distance from the gas-bag. This is one of the advantages claimed for the semi-rigid type



The Urbanity Airship. Rear View of Car.
Presented to the British Government by the "Morning Post."



The British Naval Yard

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over the non-rigid airship, which can only be anchored from the car at relatively a great distance below the gas-bag."

The safety of the airship is further considered in the springs which are provided to avoid the shocks of landing.

"The car consists of a horizontal metal flooring. Beneath it are a rigid framework, which renders the car indeformable, and the two landing pivots. Above the flooring there is a rail 4 feet $3\frac{1}{2}$ inches high, closed in in the bow with aluminium plates, and in the stern with metal gauze or grill. The interior is divided into compartments, all of which communicate from stem to stern, and are used for the following purposes :

"(1) The compartment of the look-out men or passengers is right in the bow, so that nothing may interfere with the view. Its shape tapers towards the bow.

"(2) The compartment of the aeronauts, where the pilot and one or two assistants are stationed to direct the course of the airship vertically and horizontally, with the wheels regulating the planes and rudder, and all the machinery controlling the vessel beside them.

"(3) The compartment for the landing apparatus, guide-ropes, anchors, and 'serpents,' for use either on land or at sea. The serpent for land use consists of a heavy cable sheathed in canvas and attached to a long light rope. It is thrown overboard just before landing. In this way the balloon is lightened, but it is only necessary to pull on the rope attached to the serpent to

bring the weight of the cable again into action. The serpent for use at sea works on the same principle, but consists of a number of blocks of wood united by a rope that will float on the surface of the water.

"(4) The compartment of the chief mechanician.

"(5) The compartment of the motors.

"(6) The stern compartment for the assistant mechanicians, additional passengers, ballast, reserve petrol, and so forth.

"The car can carry twenty persons."

Two 135 h.p. motors drive the large red propellers mounted on riggers on either side of the car, at a speed of 360 revolutions per minute.

The envelope of the ship is considerably longer and narrower than that of other Lebaudy vessels; and another notable feature is that there is an air space between the envelope and the rigid keel, or girder. The nose of the ship, as usual, is very sharp, and the car is mounted on a single pivot, so that the whole craft can be swung round in any desired direction.

It can be seen from this description that the "Lebaudy" is a very scientifically constructed vessel.

Now as to her efficiency. On October 26th, 1910, this airship flew with perfect ease from Moisson, in France, to Aldershot, crossing the north of France in two hours, the Channel, at one of its widest stretches, in two hours and a quarter, and the South of England in one hour, against an unfavourable wind. The description of the

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voyage, published in the *Morning Post*, is interesting, as giving the impressions of the airship traveller.

It runs as follows:

". . . The crew and passengers of the airship, M. Julliot, constructor of the airship; M. Capazza, pilot in command; M. Léon Berthé, second pilot; MM. Debrabant, Boutteville, and Lucas, mechanicians; Major Sir Alexander Bannerman, and myself took our places in the car, and the operation of weighing began.

"'We must rise at once,' said M. Capazza, 'to get clear of the hills, so we must be light.' After the first experiment, 130 lb. of ballast was removed, and then the order of 'Lâchez tout' was given. We rose gently and steadily. It was the first time that I have been in a balloon of any kind, and the impression made upon me was not that the airship was rising, but that the earth was gently falling away beneath us. There was no feeling of danger or giddiness, but simply an idea that one was rising into a new and peaceful world.

"The wind was south-east, and carried us down towards the shed. To the inexperienced eye we were dangerously near its roof, though the barometer showed that we were far above it at an altitude of 400 feet. We were still rising as M. Berthé poured down sand ballast through the funnel when, at 10 a.m., M. Capazza ordered the motors to be started. At once the impression changed; the world of the upper air still remained very distinct from the world below, where tiny

men were running about and cheering, but it was no longer a world of peace; on the contrary, a world of noise and commotion.

"The screws began to revolve, and as she got under way M. Capazza swept round her helm with a force and agility that was marvellous when it is remembered that he was suffering from the effects of a motor accident that had injured his hands and left knee. M. Berthé set the elevating planes at an angle to make us rise with one hand, while he poured out the ballast through the funnel with the other. As I was standing just forward of the motors, I felt no rush of air, and could only tell that we were moving by watching the ground below.

"M. Capazza set his helm straight towards the Castle of La Roche Guyon, and we crossed the line of hills that fringes the Seine at a height of about 300 feet. M. Julliot had decided to carry most of the ballast in the form of petrol, and a certain number of tins had been thrown out while we were over the plain of Moisson. As we passed over La Roche Guyon, steadily rising, several red, white, and blue ribbons marked '*Morning Post* Airship' were thrown overboard.

"There was no feeling of fear or discomfort; the airship was far too steady. The scheme of values had changed, and before one could take reasonable observations one had to grow accustomed to the idea that the little boxes below one were houses, and that all the tiny things below one looked quite large when one was on the ground. In a few minutes, however, this feeling passed away.

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"More petrol tins were thrown overboard, and one could watch them falling steadily for many seconds, until as they struck the ground they smashed out flat and the petrol squirted out in a spray like steam. Rabbits, worried by the noise of the propellers or the shadow of the airship, were plainly visible to the naked eye as they scuttled across the plain, though horses and cattle scarcely looked larger than dogs.

"As we passed over the valley we began to realise that the south-east wind was by no means at our stern when we were on a south-western course, but M. Capazza kept the airship's nose up against the wind and we forged ahead at a speed that could only be realised by watching the motors below that were doing their 40 miles an hour. Sometimes in undulating country we met up or down currents which were to the airship just what the waves or swell are to a ship at sea; the nose of the balloon rose or fell and she began to swoop upwards or downwards, but in an instant she steadied herself as M. Berthé brought the elevating planes to maintain her equilibrium. The stronger the wind and the more precarious the currents, the greater was the triumph of M. Julliot's design.

"At 10.35 we sighted Les Andelys, and had a magnificent view of the Château Gaillard beneath us. For a time we followed the railway line, which looked like a child's plaything, and then swept across the Seine. M. Lucas, the mechanician, then gave us a splendid example of the possibilities of dropping bombs from the

clouds by neatly throwing two petrol tins into the river.

"The sun was behind us, and the right propeller as it whirled in front of us produced a curiously dazzling effect. Again we had trouble with a side wind reflected from some cliffs, which turned the airship from her course and made her dive; but in a minute the rudder and elevating planes regained the mastery. . . .

"We passed over many 'châteaux' that looked like little dolls' houses. The mechanicians, sure of their motors, which were running with the musical hum that told to their expert ears that all was well, amused themselves by waving cloths to a ploughman who had all he could do to keep his frightened horses under control as the shadow of the gas-bag passed over them.

"At 11.30 the French coast was in sight. M. Debrabant opened a trap-door beneath my feet to see the part of the motors which lies beneath the floor, and I must admit to a slight feeling of discomfort at the sight of a drop of 1,000 feet down to the green fields below over which my feet were swinging as I sat on two cases of lubricating oil; but I have been far more giddy looking down from a cathedral tower.

"At 11.50 the captive at St. Valery-en-Caux, a yellow patch against the grey haze, was visible, and we steered boldly towards it. For the first time we realised the strength of the wind. The captive was heeling right over, and we could see the white foam on the swell blown across our course. The waves seemed tiny beneath us, but

a little thought showed that there was a lively sea on.

"A white steamer was in sight with sails set, apparently for the English shore, but for some time we could not see the low-lying destroyer in the haze. Soon, however, we sighted her and heard her siren; she at once set her course straight for Brighton, and our pilot took his bearings from it. The splendid success of the 75 miles journey across the sea is the best proof of the exactitude of the course given.

"At noon exactly we crossed the cliffs, and had the most wonderful view of the coast-line in the sunlight stretching for miles on either side. At an altitude of 1,600 feet we passed the destroyer, which seemed to be moving slowly, though from her wake she was going at full speed. The boom of two guns told that we had been saluted by the warship, and she was soon far behind us. M. Capazza kept us steadily to the west of the course set by the destroyer to allow for the wind, and to us on board it seemed that we made a great curve across the Channel.

"There was a sense of security in being above the waves, that seemed so small beneath us, cut only by the flash of the sun on a seagull's wing, and the serving out of life-belts seemed ludicrously unnecessary when one looked up at the great yellow sides of the gas-bag that supported us. The head mechanician set himself astride one of the reservoirs above the car and, contentedly whistling, filled it from the store of tins.

"For a time, however, we realised the solitude

of the sea. We had lost sight of the destroyer and not a vessel was visible. At 1.10, however, we sighted a range of clouds which told of land behind, and M. Capazza steadily steered his course to the west up against the wind. It was only at 1.40 that suddenly through the clouds a long grey line, like the back of a phantom ship, loomed out below us, and we knew that it was the English coast.

"We steadily made towards it, the bow ever turned towards the west, and through the glasses made out Newhaven Harbour. Then we bore down towards the east, and at 2.18 the shadow of the airship touched the sands beneath the town of Rottingdean. . . .

". . . . At 3.15 we passed right over Charterhouse, and at 3.28 we announced by siren that we had sighted the shed at Charterhouse. Then came the hardest part of the journey. We had to fight against a wind of at least 25 miles an hour absolutely against us, and we began our descent from a height of 1,600 feet. As we descended the elevating planes came more and more into play. Everyone on board was expectant and ready. MM. Capazza and Berthé had their knives ready, and then as we went down M. Capazza called for more power from the engines. At once they were put at full speed—1,000 revolutions a minute—and we began to gain a little on the wind.

"M. Berthé's knife flashed and the guide-ropes were cut; the men below had just seized them, when the chain of the rudder slipped off the sprocket wheel owing to the strain. The

ship was kept steady by the cords that double the chain, and after some minutes the chain was again in place, but the wind had carried us a mile or so away. The motors, however, were running perfectly, and we came up again in the very teeth of the wind. The serpent was cut loose, and the men at last got a hold and brought us down. 'Gently,' was the shout of all those in the car who could talk English. 'Gently.' The word was obeyed, and the car was received on the shoulders of the men, the motors were cut off, and all was over."

Such was the famous voyage of the "Lebaudy," and it gives a good idea of the feelings of a passenger in such a ship.

Before leaving vessels of the Lebaudy type, it is necessary to refer to the deplorable accident which befell one of the French military craft—the "République"—in 1909. She had become a familiar object to French troops on manœuvres, and every belief was entertained as to her safety. On the fatal morning of her last trip, in September, she set off, carrying two officers and two N.C.O.'s, from La Palisse to Chalais Meudon, followed on the road by staff officers in motor-cars. She had travelled barely half the required distance when one of her metal propeller blades snapped, from some unexplained cause, and flying upwards with terrific force ripped its way through the envelope as a knife might cut through a lard bladder. The ordinary balloon would have formed itself into a parachute in circumstances like this. But with the airship the case was different. The envelope

crumpled up, and the whole craft dived forward, from a considerable height, while the crew tried to jump from the wreckage. A brief vision of flapping, torn envelope and falling machinery, and the disaster was over, all the luckless voyagers being killed instantaneously when the car hit the ground. This accident served to direct attention to the extreme importance of having an absolutely reliable propeller fitted, and metal blades gave place to wood.

The Gross semi-rigid dirigible is of German origin, and a certain amount of secrecy is preserved with regard to the details of the various vessels of this type. This is only natural, as a good deal of use is made of her for military purposes. In appearance she is not unlike the Lebaudy type, although she lacks the shark-like nose which is so characteristic of the French ships. Her envelope is on the ordinary lines known as "fish-shaped," being rather bluff in the bows, and tapering more finely aft, to the tail.

Beneath the envelope is fixed the keel girder, usual to semi-rigid ships. It is occasionally formed of aluminium tubing, welded together, and sometimes by a steel lattice-work. The car is boat-shaped, and as a general rule is suspended at a considerable distance beneath the keel, in order to facilitate the distribution of the load. The envelope contains two ballonets.

For horizontal steering a large vertical rudder is provided, while in order to increase the stability of the ship fins are situated on either side of the tail. To aid the vertical steering horizontal

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aeroplanes are used, and Daimler motors in the car drive either four or two propellers at high speed, to drive the ship. A particular novelty in the construction of the vessel recalls the design of the Barton airship, to which I have already referred. Two water tanks are provided, one in the bow and one in the stern, and by blowing water from one to the other either end of the ship can be raised or depressed at will.

The Gross airship has made many voyages with conspicuous success, but most of them have been conducted in connection with manœuvres of the German Army. To the soldiers of the Kaiser she is a familiar sight, and correspondents have described her as resembling some great fish as she circles above their heads, yellowish in colour, with the tackle of the wireless apparatus dangling far beneath her bows.

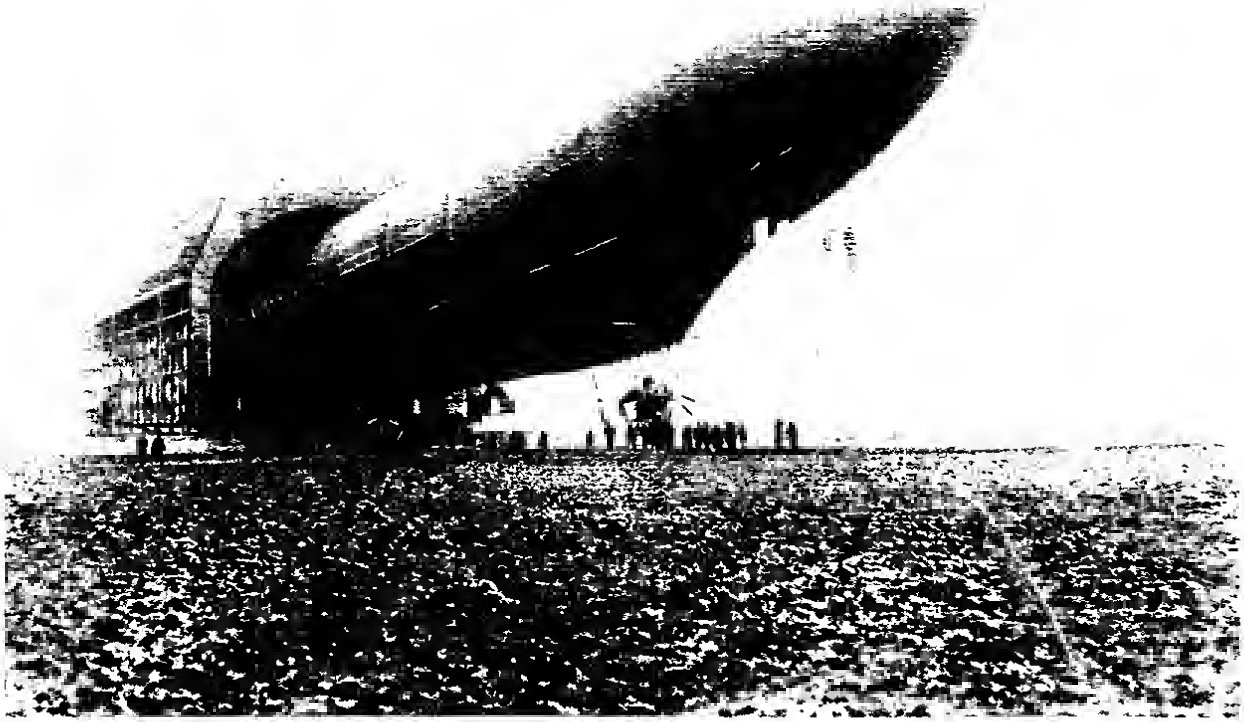
The " Siemens-Schukert " is another semi-rigid ship of German design, built by a private company. She made her first trip at the end of January, 1911, and at the time of writing full details of her construction are not available. From the pages of the weekly journal *Flight* I have, however, obtained the following particulars :

" The airship, which has been built for military purposes, was actually completed last March, but then it was found that the envelope was not strong enough, and accordingly it had to be taken to pieces and reconstructed. The envelope is some 387 feet long, and 43½ feet in diameter, and has a capacity of 31,000 cubic metres. Three cars are fitted, the centre one being for passengers,

while those at the fore and after end of the balloon are for the machinery. Each of these two cars contains two German Daimler motors of 125 h.p., one driving two propellers, and the other a single one. There are six propellers altogether. It is claimed that the airship can carry fifty passengers."

On her trial trip she made a successful journey over Berlin, carrying twelve passengers.

I will now turn to another ship, which has earned fame. This is the Wellman airship, which was finished in 1910. Her builder had for some time been making plans for reaching the North Pole by airship. Suffice it to say that these attempts were not successful, and in 1910, in the month of October, he attempted, under the auspices of the *Daily Telegraph* and an American newspaper, a feat which was almost as hazardous as his projected Arctic voyage. This was the crossing of the Atlantic Ocean, and though the attempt has sometimes been scoffed at as being from the start an absurd one, yet it is undoubtedly a historic voyage. No one can deny the pluck of the inventor and his crew who set out to challenge Neptune in one of his greatest domains, for the first time in the world's history, in an airship. The Wellman airship was in length 228 feet, with a cubic capacity of 345,000 feet. Beneath the envelope was a car of steel tubing, 150 feet in length, and below that again was slung a lifeboat, well provisioned and fitted with a full supply of instruments. Two 80 h.p. motors drove four propellers. One of the principal features in the ship was the employment of a long chain of



The Gigantic Airship of the Siemens-Schuckert Works at Berlin

metal tanks, known as the equilibrator, which was intended to regulate the height of the airship. Normally the craft would keep at a certain elevation. Should she sink, however, a greater part of the equilibrator would be lowered to the surface of the water, where some of it was already trailing. The airship, relieved of this weight, would thus be checked in her tendency to drop. On the other hand, should she rise unduly, a greater weight of equilibrator would have to be lifted from the water, thus again checking her automatically.

As a matter of fact, it was the equilibrator which largely caused the failure of the voyage, as the great Atlantic waves, hitting and pulling it, caused it to wrench the whole structure of the airship in a most dangerous manner. Another point in the ship's construction was the employment of no less than six ballonets, for as the motors used up the gasoline the ship became lighter, and in order to check an increasing tendency to rise it was found necessary to fill the ballonets with air. Naturally the step of getting rid of hydrogen was not resorted to until absolutely necessary.

By the courtesy of the editor of the *Daily Telegraph* I am enabled to quote from descriptions of the actual voyage, which, rash as it may have been, was certainly as romantic and adventurous as any voyage in fiction. The first quotation taken from the journal will give you a good idea of life aboard the airship "America" during her transoceanic passage.

"It is fascinating to imagine the life of that daring crew who have now been three days in the air. There is not much room for comfort aboard the 'America.' True, her car is more than 150 feet long, and a gangway runs from end to end. But that gangway has no more than width enough for the airmen to go about their business. True, there are bunks of stretched canvas, with a canvas screen to keep off the wind. But a man need be careful not to turn over in his sleep lest the airship lose one of her company. Perhaps he is not likely to sleep too soundly, even after keeping watch in the Atlantic breezes, for his bunk is just over those two 80 h.p. engines which drive the 'America' on her way. You picture the long shape of the 'America' looming between you and the sky. In among the avenues of steel stays that look like gossamer move a few tiny figures, khaki clad. One stands his watch by the thudding engine amidships. The blue-coated navigator is forward by the binnacle. So she passes on her course. But no one of those men can afford a moment to rest and be careless. There is no room to relax and stretch at ease. Thought and limb must be always alert. There is no shelter but a canvas screen from wind, or wet, or the airman's ever-present enemy, cold, and this for day after day and night after night. . . .

"All the more honour to the men who have set themselves to achieve it. Whether they succeed or fail, the history of the voyage of the 'America' will always hold a famous place in the chronicle of what men have made of their world.

The days of loneliness, with nothing in sight but grey sea and sky, while each man's mind is strained and eager to the limits of his power about his own peculiar task—the navigator at the wheel, the engineers with ears keen for the sound of the sweet-running pistons. Or, if you please, let it be the middle watch of the night, with the weird shape driving onward between black sea and violet, star-spangled heaven. The men off watch lie still, cramped in their narrow bunks. Only the man at the wheel, with his eye seeking the bearings of the stars ahead, only the engineer by those thudding cylinders, are alert. Here is loneliness, indeed, for on the single skill of each man it may rest to win success or bring death upon all. The only sounds are the whistling of the wind through the steel cables, the beat of the engines, and the splash of the fathomless sea beneath at the equilibrator. The man on watch is cut off from all human help. There are no rules to guide him in this fight, for the fight has never been fought before, and he is matching himself alone against all the wild powers of the universe."

The "America" sailed from Atlantic City on Saturday, October 15th, 1910, the whole ship weighing then some 13½ tons, and headed north-east at 25 miles an hour. A wireless message was received not long after the start mentioning that the waves were causing the equilibrator to jerk the airship unpleasantly, and after that no message was received for some time. Subsequently the crew of the ship were picked up by the Royal Mail steamship "Trent" at a time when, in Mid-

Atlantic, she was heading into a furious hurricane, that would doubtless have destroyed her. As it was, the ship herself, when the crew had left her, rose from the waves, and vanished, being lost somewhere at sea. I am enabled to take the following interesting account of the journey from the *Daily Telegraph.*

"The laurels which the 'America's' crew, in their soiled brown uniforms, brought back to land are summarised here as follows: A new world's record for time in air in any air-craft except a drifting balloon—71½ hours, according to the official log of Mr. Simon—a new world's record for distance travelled, the computation of the navigator placing the figure at 1,008 miles, the honour of sending the first wireless messages ever received from an airship off the ground; the strange distinction of being the first wrecked aviators to be rescued by a ship at sea after having abandoned their craft to be a derelict of the seas; and, finally, the satisfaction of a glorious attempt to win the bravest laurels of the transportation world. . . .

"We were a happy half-dozen," says Mr. Wellman, "that foggy Saturday morning when we set sail from Atlantic City. Our months of arduous work, day and night, preparing the great airship for her voyage, were at last finished. We had struggled against many difficulties and delays, and endured many misunderstandings, criticisms, and suspicions, but now we were to have our chance. We were on the way, stealing almost noiselessly out into the thick pall which lay

heavily over the Atlantic Ocean. We were off on a voyage whose end no man could foresee."

He realised, Mr. Wellman says, the desirability, and even the necessity, of a trial trip; but he states that, with the season so far advanced, and stormy November hastening on, to stop for a trial would probably have meant no voyage whatever this year.

"We preferred our adventure," he continues, "no matter what its outcome, and the criticism which might follow having it with an untested ship, to the more prudent method of preliminary trial trips, to be followed inevitably by criticism because there was no adventure at all."

"From the very first day the airship's troubles, despite a calm sea and absence of wind, began. Though months had been spent by the best-procurable mechanics in their preparation and trial, the motors balked at the start, and balked badly.

"Motors, like men, are strange creatures: one can never feel quite sure of them; and within a few hours after our great ship, lifting her twelve tons in the air, and dragging two tons more in the water underneath her, had stolen out from Atlantic City into the foggy space to the eastward, we knew that the better of our two large driving engines was virtually out of commission, and that we should be able to get little work out of it.

"But one good engine remained, and with that we should go on. It, too, proved coy and uncertain, and from eight o'clock in the morning until six in the evening of this first day we had the

motor running not more than three or four hours, which was not an auspicious start. This explains why we were only some sixty or seventy miles from our starting point when we were passed by an outward-bound steamer that evening."

Mr. Wellman credits the resourceful and indefatigable Mr. Vaniman with being able to repair a motor at sea. Then followed a long all-night battle, the airship fighting its way with one set of propellers against the wind inch by inch, a hard, tough fight all the way, and the gallant Simon still at the wheel, where he remained almost at one stretch for twenty hours.

"Showers of sparks escaped from the red-hot exhaust-pipe and flew backwards with terrific force in the strong currents produced by the propellers, and illumined the varnished canvas sides of the car and the silk cotton envelope of the great balloon. It was with strange and not wholly pleasant feelings that we stood and watched these aerial fireworks.

"The combination of belching fire, 345,000 cubic feet of highly inflammable hydrogen, and three tons of volatile gasoline was not one to inspire confidence and contentment. If just one out of those thousands of sparks were to find a lodging-place in a seam, or the edge of a valve, or in the rudder, or in the folds of the ensign of the Aero Club of America, which we so proudly flew at the ship's stem, a small blaze might follow. And a small blaze inevitably meant a larger one before we could bring into play the fire extinguishers which we carried on board, and that larger flame

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communicating with the gas or gasoline meant—well, just the end of all things."

Sunday morning, the day after the departure, found the adventurers well out upon the ocean, heading towards Europe, and though doubts and fears about the equilibrator were raised, every moment the aerial sailors "felt it a joy to keep pressing along." Sunday night was a terrible experience.

"The steel sea-serpent of the equilibrator, with its two tons weight, rode heavily in the seas. Its drag in the water acted like a sea anchor upon the ship, and, in the gusts of wind and surging waves, dragged her down towards the surface of the water. It became a serious question if we could keep her afloat, and the danger was that in the heaviest of these gusts and the strongest pulls of the drag-rope the ship would be forced so near to the crests of the waves that the lifeboat would strike and be torn loose from the shackles. Loss of the lifeboat meant simply the loss of our lives, if ever it should become necessary to bring the 'America' down to the sea away from land and help.

"There was another danger: that the pull of the equilibrator tackle upon the steel car of the airship would snap some of the steel stays and weaken the structure and lead to its collapse. Should the car break up under these strains, the result would be that the balloon would break away from the weight-carrying framework underneath her, leap towards the heavens, and permit the car, its machinery, and crew to shoot down

into the depths. For six or seven hours this decidedly unpleasant state of things continued. And still, throughout the unending struggle, the jostle and jangle of the unwieldy old equilibrator, the whirl of the motors, and the perpetual mewing of the airship's cat, the men managed to snatch intervals of sleep.

"I do not know what the experience of the others was, but in my own case I well remember going half a dozen times to sleep with this thought in my mind: 'Well, when I awake, we shall probably be down in the ocean, but I don't care if I may only sleep; and sleep, if death is nothing but a long sleep, would be welcome.'

"Monday morning found the 'America' with calmer seas. There was a time, on Sunday night, when a council was held to decide whether they should launch the lifeboat, and to a man they decided to stick to the ship. Even at the last, when opportunities came to find safety aboard the *Trent*, one at least of them said irreverently, "Oh, hang the steamer, let's go on with the 'America' as long as she has a mile in her!" . . . .

"On Monday night, after a day of gas expansion and loss, and after having been compelled to jettison a good deal of precious gasoline and break up and throw overboard the useless eight-cylinder motor, in order to keep the ship up in the air, there arose again the question: Should we try to go on another night, throwing overboard more weight to counteract the enormous cooling and contraction of the gas and the loss of lifting power after the setting of the sun?"

They could have easily taken to the lifeboat, but again they held a council and decided to stick to the ship, at least until Tuesday morning. At half-past four on Tuesday morning the "America" and the *Trent* sighted each other.

Thus ended one of the most adventurous aerial voyages so far undertaken by man—a page out of Jules Verne in real life.

Another semi-rigid ship is the "Ricaldoni," of Italian design—an extraordinary carrot-shaped vessel, designed for high speed, with a boat-shaped car. She is not of standard type, so-called.

* * * * * * *

We must now consider the third type of airship—the non-rigid class. This, as I have said, is the true dirigible *balloon*, a simple gas-filled envelope, driven by motors. The advantage of the non-rigid ship is her portability, and the ease with which she can be deflated. These advantages are particularly useful for military purposes, and that is perhaps the reason why the British Government have, until recently, paid attention only to non-rigid airships. A great number of this type of ship, too, has been built on the Continent.

One of the most peculiar features in the appearance of some of the French ships is the group of sausage-like shapes clustered at the tail of the envelope. These excrescences are either cylindrical, as in the "Astra" class, or pear-shaped, as in the "Clément-Bayard," and are used for the purposes of aiding the stability of the vessels, though it must be confessed that they do not add to their grace.

One of the most famous of the non-rigid types is the German "Parseval" class, which has many advantages to recommend it for the use of the army. In most non-rigid ships the weight of car and engine is taken by a long girder suspended beneath the envelope, but in the "Parseval" this girder is done away with, a comparatively small car being suspended directly from the envelope, at a very long distance from it. The car, too, is provided with two small wheels, running along cables attached to the balloon, and it is thus loose, and can alter its relative position to that of the envelope above, so that pitching in mid-air is avoided.

This absence of girder makes the airship very easy to pack. In addition, one of the most novel features is provided by the propeller. The blades are limp, being made of special cloth, so that they hang down when not in use like peeled banana skins! They are weighted at the ends, however, so that when the shaft, to which they are attached, begins to revolve, they fly out, by the action of centrifugal force, just as a stone on the end of a piece of string flies out if you whirl it round. The blades thus assume their proper shape automatically. This peculiarity is a further aid to portability, as the propeller presents no difficulty in its disposal in packing.

The envelope varies rather in shape, in different ships. It is generally long, fish-formed, with a bluff entry and a tapering stern. Inside the envelope two ballonets are situated, one in the stern and one in the bow, and by pumping air

into one at the expense of the other, the trim of the ship can be altered at will, so giving the vertical steering. Automatic valves are provided, and there is provision for ripping the envelope should the necessity arise. To aid stability two fixed horizontal planes are situated at the tail of the ship, above the vertical rudder.

The ships of the class vary in unimportant details, but all of them have been found very efficient, and undoubtedly the type is successful, so that it has been adopted largely for army use. The vessels are not of great bulk, reaching a length of about 197 feet, carrying Daimler motors of 100 h.p. Their speed is over 30 miles an hour, but, as I have mentioned, the "paper" speed of an airship is often considerably above its practical speed. The car, as a rule, is formed of nickel steel bars, of special strength, and is fitted with the usual navigating instruments and control apparatus. In one of the later ships, its length is 22 feet, and it is suspended at a distance of 40 feet below the envelope. The "Parseval" ships have made very useful voyages, and considerable faith is placed in them by authorities across the North Sea.

In France vessels of the "Astra" class, from which developed the "Clément-Bayard," are very popular. The "Ville de Paris," used now for instructional purposes, the "Clément-Bayard," a British Army vessel, the "Colonel Renard," "Ville de Nancy," "Ville de Bruxelles"—a Belgian vessel—and various others are examples of the type.

They are all non-rigid, the long girder beneath the envelope taking the weights of car and engine. As I have mentioned, the characteristic which first catches the eye is the presence of the stabilising bags in the tail. In the "Astra" and the "Ville de Paris" these were cylindrical. They became pear-shaped in the "Clément-Bayard" and most of the subsequent vessels. The "Clément-Bayard," it will be remembered, was purchased by the British Government after making a very successful voyage from Paris to London, in October, 1910. She was housed at Wormwood Scrubs, in a prodigious airship garage, specially built by the *Daily Mail*—another journal which, like the *Morning Post*, has made many patriotic and praiseworthy endeavours to stir up public opinion in regard to aviation and the mastery of the air.

The "Clément-Bayard" is 251 feet in length, her big yellow envelope of rubbered fabric having capacity of 247,000 cubic feet. The car and engine are situated in a long girder, and carry two Clément motors of 130 h.p., which are situated one on each side of the car. These engines drive two Chauvière propellers, situated on either side, and they are, in addition, fitted with a special two-speed gear. Horizontal planes at the tail and a big rudder enable steering to be accomplished. The "paper" speed of the airship is over 30 miles an hour.

In most of these airships the weight of the girder is distributed equally along the envelope, by means of lines running from canvas bands

sewn to the gas-bag. Air ballonets are, of course, provided, to ensure the rigidity of the envelope, which has of necessity to be kept very taut in order to lessen the resistance. Full provision in the shape of automatic and hand-worked valves is also made. In the "Ville de Paris" the propeller is placed in front of the ship, screwing its way through the undisturbed air and pulling the vessel instead of pushing it.

I do not intend to describe all the vessels, the names of which I have mentioned, as their details are somewhat similar, only differing, as a rule, in bulk, and my readers will probably find it sufficient to know something of the general type, instead of studying the measurements of each separate vessel. Suffice it to say that these non-rigid ships are popular on the Continent, and that a number of them are owned by private individuals as well as by the various Governments.

The British Army, in addition to the "Lebaudy" and the "Clément-Bayard," also owns one or two non-rigid vessels. The old "Nulli Secundus," which was rebuilt and enlarged after her first voyages, was one of the number. She was sausage-shaped, her envelope being very carefully built up of gold-beater's skin—the most expensive of fabrics—and was provided with neither ballonets nor stabilising shapes, while four broad bands passing round the envelope, from which the car and girder were suspended, gave her a quaint, zebra-like appearance. She was quite small, being only 112 feet in length. Two pro-

pellers were provided, and horizontal planes in the stern were used to aid the vertical steering. She made one successful journey from Farnborough to London, in 1907, being then piloted to the Crystal Palace. A blustering wind arose, however, and in order to avoid the possibility of her being carried away, the envelope was ripped. She was subsequently rebuilt and enlarged. Then came the dirigible "2," an airship of larger size. She is 150 feet in length, her envelope being fish-shaped and provided with stabilising shapes at the tail, which communicate with the interior of the balloon by means of two small apertures. Two ballonets are also provided inside the gas-bag. The car is built in three parts, consisting of a central division made of hickory, and two end portions of steel tubing. Two Green motors of 50 h.p. drive two propellers, one on either side of the ship. These propellers are so fashioned that they can be tilted, so as to drive almost vertically up or down, this aiding the ship to rise and descend. A horizontal rudder is carried at the stern, and at either end of the frame are two horizontal elevators. The speed of the vessel is 28 miles per hour—not high enough to make her of much service save in the calmest weather. She has, however, proved as efficient as expected.

"The Baby" was another dirigible of diminutive size, built for instructional and experimental purposes. Her fish-shaped envelope only had a capacity of 40,000 cubic-feet. Her engine developed 30 h.p. Two stabilising shapes were

fitted at the tail of the gas-bag, and the girder car below, carrying the engine, was provided with two horizontal planes. She was a useful little vessel, in spite of her small dimensions, and taught the hard-working balloon staff at Aldershot several valuable lessons.

Other work is progressing well in the Army sheds, meanwhile, and other ships are under construction. Undoubtedly, with the Lebaudy and Clément-Bayard ships as the backbone of the fleet, a good step has been made; but, compared with Continental enthusiasts, we have so far done little in the way of aerial work, and can only hope for better things to come.

Leaving the British Army, I must now describe one or two other vessels before closing this chapter and saying good-bye to airships as we know them at the present day. A type I have not yet described is the "Zodiac" class of French ships. This class is the outcome of efforts to build a cheap, small pleasure-vessel, which can be easily transported and manœuvred, and can, in addition, be inflated with coal-gas. In spite of the peaceful objects for which this ship was originally designed, however, she is now adopted by Russia and France as a military vessel to be used for scouting purposes. Ships of this class are cigar-shaped, and quite small—usually not reaching to a greater length than 100 feet or thereabouts, with a maximum capacity of 30,000 cubic feet. The gas-bags are of varnished silk or cotton, and are fitted with valves and ripping panels. The engine is of moderate horse-power, driving a pro-

peller at the stern of the ship, while a vertical rudder in the rear and a horizontal plane in front assist in the manœuvring of the craft. The ship can be deflated and packed for transport in less than an hour.

Americans have so far devoted more attention to aeroplanes than to airships. Their Army Staff have, however, produced the Baldwin type of non-rigid vessel, which is efficient, though not of remarkable importance. The "Baldwin I." is spindle-shaped, the envelope being 96 feet in length, with a capacity of about 20,000 cubic feet. It is provided with one ballonet, and is built of Japanese silk, with a layer of rubbered fabric. A spruce car, or girder, carries a 20 h.p. Curtiss motor driving a propeller at the fore end, which is designed to give a speed of nineteen miles an hour. At the fore end of the car is a big biplane elevator, operated by a lever, while the vertical rudder at the rear has horizontal planes fixed to either side for aiding stability. Only two men are carried, so that the ship is scarcely to be compared with the great Continental vessels.

And now I must leave modern airships. I have not attempted to describe various non-standard ships, of quaint design, which have been built in Italy and Spain and other places. As a rule, these airships have done little of importance and have not caught public attention as the standard ships have done. True, the little Willows airship, of British construction, made a good journey from Cardiff to London, and again to France. But if once a beginning is made to describe every

airship or aeroplane which is off the track, so to speak, the task becomes colossal, and technical details are apt to pall upon the reader.

As to the future of airships I shall have something to say later on. Meanwhile my readers have now seen something of the development of the dirigible craft, from the first crude effort made with oars and sails to the latest giants of the air, lying snugly in their harbours all over Europe, sallying out now and again, like gold-fish rising from the bottom of a pond, and only waiting for an opportunity of showing their powers in earnest. For, after all, it is only by actual test that their values can be shown; and, in the aeroplane, they have a very deadly rival of recent development waiting to tackle them in mid-air.

CHAPTER VIII

The Aeroplane Develops

As I have said, while Lilienthal and his followers were tackling the problem of flight from the human control point of view, there were still a number of scientists and inventors whose work followed the older line of progress. These men made notable attempts to establish their mastery over the air. But they attacked the question from another side, seeking to build right out a machine more or less perfect, in which men might be taught, automatically, as it were, the way to fly. This was the reverse of the Wrights' method. "Teach yourself to fly first, and then build your aeroplane," was their motto, and it must be confessed that their method had the best results.

Nevertheless, it must not be supposed that the work of the men whose names are to be mentioned in this chapter was entirely negligible. They are very well known in aeronautical history, and to one of them, Ader, a French electrical engineer, probably belongs the honour of having built a monoplane which made the first real free flight in history. This notable event occurred in 1897.

Ader had long been interested in flying from the engineering point of view, and had spent a large amount of time and trouble upon the planning of sundry machines, of varying designs, which

were intended to rise free from the earth. It seems that his main idea was that flying machines would, if once perfected, prove of inestimable value to the nation which was first enabled to use them for military purposes; and, being patriotic, he devoted his attention to building a monoplane which might give the French nation this advantage over all others.

His machines were all of rather quaint design. A kind of rectangular, upright box on wheels carried the pilot and engine—its appearance is grotesquely reminiscent of the showman's Punch and Judy box! In front of this construction were two large, four-bladed screws, of rather thin and "stalky" shape, far more fragile than the great propellers in use to-day. The most notable feature of the machine was, of course, the planes, which were spread out widely on either side of the pilot, and were modelled exactly upon the shape of a bat's outspread wings, curved, and "frilled" at the outer edges from rib to rib.

One or two of these machines were built, and on a later type the wings measured no less than 54 feet across, while the weight of the whole affair was 1,100 lb. Its construction occupied some years, and the French Government thought so well of the invention that they advanced a sum of £26,000 to Ader, to help him in his work.

The wings were of silk, but were not intended to beat the air in any way, despite their business-like appearance. They were merely planes, for supporting the machine, and all the driving power was provided by the screws, which were

turned by a four-cylinder steam engine of very secret design, developing about 20 h.p. As in modern machines, the Ader aeroplane, known as the "Avion," was started by rolling along the ground until its speed was great enough to cause it to rise; and in 1897, after a long period of earnest work, the machine actually flew for some little distance.

This result was considered to be so encouraging that the French War Department arranged a day for an official demonstration of the aeroplane's capabilities, and with every hope of a great success Ader prepared to fly. A gusty wind was blowing across the ground when the military commission assembled, and no sooner had the inventor taken his place in the machine and started his engine than it was evident that no flights worth recording were to be made on that day, at all events. The machine rose, but could not battle with the wind, and eventually the Government authorities hinted that they did not consider that they were justified in helping Ader to any further extent. This disheartening verdict caused the inventor to give up his experiments, and the "Avion" eventually found its niche in history in one of the great Paris museums.

It was an instance of "bad luck." It is quite possible that, had the experiments been continued for long enough, Ader's name might have been rendered even more famous.

Another Frenchman deserves to be mentioned here. This is M. Tatin, who, in the year before Ader's public failure, was engaged upon the

construction of a model flying machine of rather novel type, something like a Blériot monoplane in appearance. Tatin was an earnest student of aerodynamics, and, setting to work in a scientific way, succeeded in making his little aeroplane fly. It was eventually lost in the sea, however, and as the experiments were of a very costly nature they were discontinued.

It is interesting to note here how universal was the interest taken in flying at this time. The scene of experiments is continually shifting, and names of varying nationalities become known. Now, for instance, we must leave Europe for the time being, and look across the Atlantic to the United States in search of our next inventor.

In this great country aviation was making steady progress, and in 1893 Professor Langley began to make experiments with flying machines. Langley did not go rashly to work. He was a scientific man, and preparatory to constructing his famous model he made earnest investigations into the mathematical problems of flight, aiding his work by many "laboratory" tests, useful in the calculation of aerial resistance, strains and the lifting powers of surfaces. He was helped by Dr. Graham Bell, who himself did a great deal of notable work in connection with kites of cellular design.

Langley's experiments were from the start useful, for by them he proved that certain figures drawn up by a French mathematician in reference to aerodynamics were entirely wrong; and a number of new laws and theories were

established by him, the knowledge of which proved of the greatest service to him when he began to build his model machine.

This model had a picturesque and workmanlike appearance, resembling a double monoplane of "Antoinette" design. It had a main backbone of steel, to the centre of which was attached a boat-shaped carriage for the engine. At the bow of the machine, just in front of the carriage, were two broad rectangular planes, covered with stretched silk, one on either side of the backbone, set at a dihedral (widely opened V), angle, and braced by numerous wires. A similar pair of planes, at a similar angle, were situated in the stern of the machine, and between the two planes, one on either side of the car, were two screw propellers. Right astern was a tail, consisting of horizontal and vertical surfaces.

The large model attracted considerable attention, owing to the ingenuity of its construction and to its performances. Langley himself relates the tale of his great difficulty in finding an engine of sufficient power and small enough weight to make flying possible. It was only after a long period of experiment that he had the satisfaction of seeing his machine fly splendily, starting from the roof of a houseboat on the river Potomac. This was in the year 1896, and quite a number of encouraging flights were then made, so that Langley at length decided that he would make a bold bid for success, and in 1898 he began to work upon a large machine, capable of carrying a man.

Here again he found that he was, so to speak, running with too large a handicap against him. The engine problem was proving the most serious obstacle to the accomplishment of his aims, and for a long time he was unable to secure a suitable machine for the "Aerodrome," as the plane was called. He decided to use a gas motor, but, though various firms attempted to build a machine light enough for his requirements, they did so without success, for, if the engines were light, it was found that they did not develop the required horse-power. So eventually Langley had his engine specially built under his own supervision. When finished it weighed 830 lb. and developed 52 h.p., while the completed planes of the machine had an area of 1,040 square feet.

Success seemed to be appreciably close when, in 1903, after years of work, Langley took his full-size aeroplane to the Potomac houseboat, whence his models had already flown, and prepared for man-carrying experiments. Difficulty was experienced from the first in perfecting a successful mode of launching the machine, and when, finally, tests were attempted various accidents attended the aeroplane. Finally, a lack of money put an end to the expensive work. This was the more unfortunate, as Langley's models had shown excellent form in the air—a flight of one mile having been made on one occasion. And this was certainly encouragement enough for the building of a full-size aeroplane.

Once again the scene of aerial advancement changes, for further experiments in flight were

being made in Sydney, New South Wales, by Mr. Laurance Hargrave.

Mr. Hargrave is chiefly famous as being the inventor of the box-kite, now so commonly to be seen hovering high above the tree tops. But he also devoted his attention to the building of aeroplane models. A deal of calculation and earnest work led him to choose the box form of kite for his first experiments, and after numerous flights he decided to use a team of harnessed kites to lift a man. Four kites were employed, giving a total surface of 282 square feet, and from the lowest of the team a seat was slung, in which the aeronaut could ride. The kites were strongly made, and when aloft in a stiff breeze exerted a considerable pull, lifting their inventor with perfect ease and safety to useful altitudes. The success of these trips led Hargrave to think that it might be possible to construct an aeroplane on kite lines.

The team of kites could lift a carriage containing an engine and a screw propeller. But nothing was done in this direction. Subsequently it is interesting to note, as we are dealing with kites, that Hargrave's box team was improved and employed by Cody, of whom we shall hear shortly, and used as the man-lifting, observation kite of the British Army.

As I have said, Hargrave also worked with aeroplane models, which were well and scientifically built. The framework of them all consisted of a long backbone, across the after part of which was stretched a broad plane. At the bows were arranged two flapping wings, rather like canoe

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blades in appearance. They were driven by an ingenious arrangement of elastic bands, which stored up power, as in modern models, by being twisted. This flapping-wing machine flew, but since the difficulties of building a full-size wing machine are very great, it is more in the nature of a scientific toy than a foundation stone upon which an edifice of efficient flying might be erected.

Hargrave, perhaps, realised this. At any rate, his next models were on the screw drive principle. A main backbone was employed as before, but this time the planes, set at a dihedral angle, were fixed at the bow of the machine, and just in front of them was a two-bladed screw propeller, driven by twisted elastic. The model weighed 2 lb. and succeeded in flying 120 feet.

A novel machine, with a tubular backbone and vibrating wings at the bow, followed, the planes again being set at a dihedral angle. A tiny engine, with a piston having a stroke of 1¼ inches, drove this model, the power used being compressed air, at a pressure of 230 lb. to the square inch. This little machine flew well for 368 feet. In consequence of this success. Hargrave set to work on yet another wing-flappng model, propelled by a small steam engine. With this machine various trials of thrust, and so on, were made. Hargrave, however, did not attempt to construct any full-size machine, and although his models attracted considerable interest at the time, it is upon the invention of the box-kite that his fame chiefly rests.

In France, too, in 1898, Captain Ferber was

making experiments of considerable importance with gliders. At first he endeavoured to improve upon the work already done by Lilienthal, but he was not successful for a year or two, although he tried both the monoplane and the Chanute multiplane type of machine. In 1901 he began to meet with some success, and in 1902 was using a glider somewhat similar to that employed by the Wrights.

In 1903 the name of Archdeacon became prominent. A keen student of aerodynamics, he was a generous donor of prizes for airmen, and he now began to busy himself with gliding experiments on a biplane machine. In the same year Captain Ferber fitted one of his gliders with a motor engine, driving two propellers. He did not attempt free flight with it at once, however, realising that slow and sure progress was more likely to lead to success than a rash effort, which might end in the destruction of his machine. He suspended his plane from an arm, 100 feet in length, pivoting from a lofty tower, and drove the machine round on this, very much as some of the clockwork toy airships, suspended from the ceiling by string, are driven. After a few experiments on these lines, arrangements were completed for releasing the machine when travelling in mid-air. But the motor was not powerful enough to keep the plane flying, and Captain Ferber's experiments, though kept up well, were now scarcely noted, owing to the fact that more successful developments were occupying the attention of the world.

It was in 1903 that the Wright brothers made their first free flight with a motor-driven plane. As usual, the two inventors were reticent. They were by no means seekers after advertisement or publicity in any shape or form, and only vague rumours of their success reached Europe. As was generally the case, the public refused to believe the stories that were circulated. Flight had for so long been a theme for imaginative romance that the idea of any man really constructing a successful machine seemed ridiculous. As a result, the Wrights were able to continue their experiments privately, and the "man in the street" went about in cheerful ignorance of the fact that the plains of North Carolina were witnessing the beginning of one of the most remarkable epochs in the world's history.

When the past story of the early aeroplanes is considered, it seems curious that in two countries—America and France—invention was hurrying on towards the goal of success at the same time. During the former years of experiment and failure, the countries had kept apace, on parallel roads as it were. Langley and Chanute had been working just after Ader and Lilienthal in Germany. Then Ferber, the Wrights and Archdeacon started on the same parallel lines; and these lines were now no longer parallel. They were converging, to meet at the point, long sought for, where a power-driven aeroplane would fly. It was a race between two continents, and America won—but not by a very big margin.

While the Wrights were startling incredulous

people, Archdeacon was working hard, and in 1904 we find that his name is mentioned with another, destined to become well known ere long—with the name of Voisin.

The two men went into partnership, working together, and began to conduct a series of gliding flights, and experiments of like description. You can see now how important was Lilienthal's work. His method of learning something of the difficulties and practical problems of flight from the use of gliders was being taken up almost universally at last, and the modest plan of beginning at the bottom rung of the ladder and climbing up by experience was recognised as the most promising mode of scoring success.

At the start of their experiments Voisin and Archdeacon found it rather difficult to discover a suitable ground in which to glide. They therefore adopted the plan of having their planes towed by motor-car—a dangerous and not over-successful method of working. The unsatisfactory procedure, leading as it did to the smashing of one of the gliders, was at length abandoned. In 1905, Langley's example was followed, and the inventors began to carry on their work over water, where, in the case of a fall the machine would be less liable to destruction.

The aeroplane in use was a biplane, mounted on floats of a canoe-like design. Between the upper and lower planes four "curtains" were erected, giving it the appearance of a number of box-kites, fastened together. A tail was also carried, constructed in a similar manner, but

carrying only three curtains, while one horizontal plane projected in the front of the machine, serving the purpose of an elevator, with which vertical steering was to be accomplished. It was, in fact, very similar in appearance to the early Voisin aeroplanes, which were soon to be well known to the public, owing to their successful flights, though, as I shall show, the Voisin machine has now undergone many changes.

It was obvious that, unless a species of water-chute was built, this glider would be unable to fly, save by towing; and it was this latter method that was again employed. With Gabriel Voisin in the machine, a fast motor-boat pulled the glider over the Seine, and in a short time the glider lifted and flew well.

This was a promising result. But although the water prevented catastrophic smashes when the machine dropped, the experimenters soon found that other dangers, more or less to be shunned, awaited them. A new form of aeroplane had been built by M. Blériot about this time, and Voisin undertook to pilot this over water, as he had done with the Archdeacon machine.

The aeroplane, however, from some unexplained cause, turned over, came down, bow foremost, into the lake, and sank. The anxiety of the spectators became acute when it was realised that Voisin had also disappeared, and was evidently imprisoned below the machine. After a few seconds of frantic struggling and fighting for life he reappeared; but not before the danger of water experiments with gliders had been

very completely illustrated, for had he been held but a little while longer there is no doubt that he would have been drowned.

With the characteristic pluck of the aviator, however—and airmen are a strong-nerved breed—Voisin did not allow his adventure to destroy his enthusiasm. He returned again to the Archdeacon aeroplane, and once more the scene of the experiments was shifted. It is on the picturesque, mountain-girt Lake of Geneva that we next hear of him. Here Archdeacon had removed his machine, attracted by the broad and open expanse of water which it offered. On the Seine he was hampered by the difficulty of finding a straight, open stretch where the wind could be relied upon to keep steady, and he had seen that if any further advance was to be made it was essential for him to keep his plane in the air for prolonged flights. To Geneva, therefore, went Voisin, and some further work, of a similar kind to that done on the Seine, was carried out.

And now, with the year 1906, came the growing realisation on the part of the hitherto sceptical public that flight was not only a possibility, but a very near probability. The fact was forced upon them by indisputable results. Voisin turned his attention to further experiments upon Lake Enghien, in conjunction with Blériot, and then attention was focused upon the work of a man of whom we have already heard—M. Santos-Dumont.

During these few years very little had been heard in Europe of the Wrights, though the two brothers had been scoring wonderful successes with

their aeroplane. From flights of a few yards they had actually progressed to flights of miles. In 1904, for instance, Mr. Chanute was a witness of one of their trips of over 1,000 feet in a very light breeze. It was ended prematurely owing to the tilting of the plane at a very awkward angle, which necessitated a landing with the wind astern, instead of ahead. In 1905, however, great strides were made, for in September the famous brothers recorded three long flights of eleven, twelve, and twelve miles—one of them lasting for no less than twenty minutes. In the following month the distance covered rose to 24½ miles in 38 minutes—a result which might well have justified them in proclaiming that they had at last conquered the air. They did no such thing, however. For the time being they were content to go on improving their knowledge of the air, until such time as they could bring forth their aeroplane with full confidence of being able to fulfil all their claims.

The reports of their flights, filtering through to the Press in Europe, were treated as tales engineered by American newspapermen; so that, when it was known that M. Santos-Dumont was devoting his attention to the building of a heavier-than-air machine, the Wrights were, for the time being, ignored.

Santos-Dumont had, as my readers know, given a great deal of time to, and spent a vast amount of money upon, the dirigible balloon. Being nothing if not enthusiastic, and seeing the progress that was actually being made with

flying machines, he now decided to try his luck with a heavier-than-air contrivance, and after some consideration, having been persuaded not to attempt the completion of a vertical screw machine, he built a biplane on the lines of the Hargrave box-kite. Its appearance was rather peculiar. When we think of a flying machine, we are apt to picture a dainty and graceful structure, whatever its type, but the Santos-Dumont aeroplane "14bis," as it was called, was certainly not graceful.

Two heavy-looking, box-kite planes, set at a dihedral angle, formed the main surface of support. Between them was situated a small, wheeled chassis, holding the engine and the airman's platform, from which the movements of the plane were controlled. Before the platform projected a girder, to which was attached a box-kite rudder of considerable size, for vertical steering. A 50 h.p. motor was employed to drive a two-bladed aluminium propeller at a high speed of revolution, and, taking everything into consideration, the machine looked to the eye of the novice about the least likely thing on earth to rise unaided into the air.

But the meaning of the old saying that "handsome is as handsome does" was brought home to the public in the month of October, 1906. Numerous machines, pleasing to the eye, had failed to justify their construction, while the "14bis," uncouth as she was, flew!

The historic event took place at Bagatelle, in the presence of a large crowd of spectators, and

of an Aviation Commission, sent by the Aero Club of France to view the flight officially; for Santos-Dumont had announced his intention of flying for the Archdeacon Prize, which had been offered for the first flight of not less than 25 metres—roughly 27 yards. Quaint conditions in these days of long flights!

Amid a flutter of excitement the engine was started up, and the aeroplane rolled off, trundled forward for a little distance, and then, to everyone's delight, rose free into the air to a height of a few feet. Against the background of green trees it seemed like some gigantic white insect, chased by a shouting crowd, who broke bounds in their enthusiasm at witnessing a real flight. For 70 yards the machine travelled well, and then, as it was pitching slightly, the airman stopped his engine and brought the plane to the ground, descending rather forcibly. As an instance of the excitement caused by the flight, it is amusing to note that the important Aviation Committee quite forgot to carry out their duties of measuring the exact distance covered, with the result that official records rather underestimated the length of the trip. Still, the Archdeacon prize was won easily, and Santos-Dumont had added to his fame in a most praiseworthy manner.

The Press, always the finger-post of public opinion, now began to devote a good deal of space to aviation and its possibilities. In a very few weeks Santos-Dumont improved his record by flying for over 200 yards, and aerial enthusiasts became jubilant. True, short-sighted cynics

sneered at the results, pointing out that a machine which could only travel 200 yards was not of any practical use to humanity. Nevertheless, aviation was establishing itself in Europe. Inventors who had hitherto dreamed, and kept their experiments rather bashfully to themselves, returned once more to their models, furbished up old machines and drew up fresh plans. Motor engineers began to ponder over the construction of light, powerful engines for use on aeroplanes; journalists to find "copy" in the doings of would-be aviators.

The aeroplane movement had started at last. It was like a log at the top of a water-chute. The Wrights and Santos-Dumont had pushed if off, and now it was sliding down the ways with gathering speed, to make its "splash" in the world.

CHAPTER IX

The Flying Age Dawns

THE year 1907 should be for ever remembered as the year in which the flying age really dawned. From dreams had grown realities, and when once Santos-Dumont had set the example in Europe with his box-kite machine, other men followed in his footsteps, and it was not long before quite a number of aeroplanes were in existence, most of them capable of rising from the ground.

The first successors to the Brazilian were MM. Gabriel and Charles Voisin, who, it will be remembered, had been engaged with M. Blériot in experimenting with gliders, towed by motor boats, at Enghien. These two brothers, working together, soon developed their own type of aeroplane, and early in 1907 succeeded in interesting M. Delagrange in the machine. They then endeavoured to fly it at Vincennes, but from various causes their experiments were delayed, until at length, on March 30th, the plane rose, and covered a distance of over fifty yards without any difficulty. This was an encouraging success indeed, all things considered, and before many weeks had passed there appeared on the scene a man who has made his name famous in the aerial world—Mr. Henry Farman.

He approached the Voisin brothers with plans

for a machine of his own, differing slightly from the aeroplane which had just flown so successfully. It was immediately put in hand, and as soon as it was delivered Mr. Farman set about the business of learning to pilot a machine in the same scientific manner that is practised to-day. That is to say, he did not immediately attempt to fly, but went in for a good deal of rolling practice, before, in September, he was confident enough to make his first flight of nearly 100 yards.

This was encouraging, and some of the public began to believe that there was something in the aeroplane after all. This belief was still further strengthened a few weeks later, when Mr. Farman flew for the remarkable distance of 840 yards, and then, early in 1908, announced his attention of competing for the Deutsch-Archdeacon prize that had been offered for a circular flight of one kilometre.

The actual distance of this flight was not very great, and had it been for a straight run there would have been very little uncertainty about the result. But in Europe, at all events, the accomplishment of a turning movement on a flying machine had hitherto been unheard of. Nevertheless Mr. Farman succeeded in winning the prize without any difficulty, having practised assiduously until he was sure of his ability to pilot the aeroplane round corners.

This feat spurred public opinion again, and a keener interest began to be taken in the doings of the few men who were devoting their attention to the perfecting of the aeroplane. Before long

the world had to applaud the performance of M. Delagrange, who, on a Voisin biplane, succeeded in making a flight of over two miles in a circle. This was in the spring of 1908, and the names of Farman and Delagrange began to appear with frequency in the columns of the newspapers as their various flights were reported. Two flights of over a quarter of an hour, made by Delagrange, were followed by one of nineteen minutes, performed by his rival, who won the Armengaud prize by this feat.

And now it began to be rumoured that Europe was shortly to see some aerial feats far surpassing any of these flights. It was said that the Wright brothers were to come to France, and their arrival was awaited with the keenest interest. But before the rumour was definitely confirmed, a new name and a new aeroplane had claimed the attention of the Press. M. Blériot, the real pioneer of monoplane work, succeeded in making an excellent flight.

Day by day, now, it was becoming increasingly evident that all the work and all the dreams of inventors had not been in vain, for quite a number of machines had already succeeded in rising into the air, if not in making any very long trips. Then came Wilbur Wright, ready and willing to show Europe what he could do in the way of aerial navigation, and after a few preliminary trips of short duration, he began to put in some very fine work that bore out fully all the newspaper reports of his progress at Kitty Hawk.

In September, 1908, he succeeded in winning

the Michelin prize, making a fine flight that lasted for an hour and a half, and covering about fifty miles in the air. This was flying in earnest. And by way of demonstrating the power of his machine, Wright made various trips with passengers, and straightway the illustrated papers of a continent were filled with aeroplane snapshots, and the thin, keen face of the American airman became familiar to the British public. Now, as a child builds a house of cards and knocks it over, Wright began to set up new records and to demolish them at once with remarkable regularity. Incidentally it may be remarked that aviation seems to lend itself to this pastime, since nowadays records very rarely endure for an appreciable length of time.

For the time being the work of Wilbur Wright occupied public attention to the exclusion of everything else. But Mr. Henry Farman soon created a new record by making a fine cross-country flight. This was a daring performance, and the aviator himself confessed to feeling a trifle nervous when crossing a plantation of trees, and watching for the first time the house roofs slipping away beneath him. But once his first qualms had vanished he found the flight delightful, and, landing in perfect safety, received the congratulations of all his friends.

This was good enough for M. Blériot, who promptly brought out his monoplane, and imitated Farman's feat, to his own and everyone else's satisfaction.

Then followed a time when little was done.

Farman, having now decided that there was a definite future before aviation, took up the work of aeroplane construction, while the other aviators were busy improving their machines. In 1909 a number of new airmen came to the fore, among them being Hubert Latham, with his Antoinette monoplane—a description of which occurs in a later chapter. It was early in July of that year that the announcement was made in the Press that this airman intended to make an attempt for the £1,000 prize offered by the *Daily Mail* for a cross-Channel flight, and interest was quickly aroused when it became known that the attempt was undoubtedly to take place in a very short time. Curiously enough the majority of people were inclined to look upon the feat as an essentially rash and absurd one, forgetting that already a number of overland flights had been made which in point of distance, at any rate, quite overshadowed the Channel trip.

Excitement, therefore, ran high when telegrams announced on July 19th that Latham had actually started. It was a glorious morning, and he left the French coast at high speed, followed by a tug, which was rapidly outdistanced. When he had covered nearly half the distance, however, his motor stopped, and he was forced to glide to the calm surface of the water below, and there he floated serenely until picked up.

Nearly a week later, on July 25th, in beautifully calm weather, Blériot left Baraques on the French coast in his monoplane, bent on accomplishing the feat which had been so well

attempted by Latham. Flying swiftly over the bare sandy scrub, he wheeled, heading straight for Dover. A moment later his engine was spoiling for the peace of early morning over a peaceful grey sea, as he drove it steadily towards his distant goal, where the white cliffs marked the English coast. The flight was made with perfect success, the monoplane being brought to ground safely on the Dover cliffs, where its alighting place is now marked by a stone aeroplane, which will be a historic monument in time to come. Blériot was greeted with wild excitement in England, and his machine was exhibited subsequently in London, and viewed by many thousands of the public.

Two days later, Latham, not to be outdone, made another attempt to cross the Channel, meeting with the worst of luck; for he was only a mile and a half from the English coast when once again motor troubles forced him to come down to the water, where he was picked up by the vessels which had followed him on his way.

The cross-Channel flight is undoubtedly one of the most notable events in the history of flight. It will be said in the future that it was from the moment when Blériot's monoplane came to rest that England began to lose the name of island; for once our narrow frontier of sea can be crossed regularly and with ease by piloted flying machines, our position approaches more closely to that of a country on the mainland of Europe. At any rate, Blériot's flight was of the greatest service in rousing public interest and curiosity, and when

shortly afterwards the first flying meeting ever held took place at Rheims, the Press devoted columns of space, bold headlines, and staring "bills" to describing the wonderful sights to be seen at the town.

Writers went into ecstasy over the feats of the pilots. They became still more enthusiastic over the spectacle of a whole "covey" of aeroplanes in the air at one and the same time, passing one above the other, whirring round the course, now silhouetted like black paper against the sun, now sailing like white gulls into the full bath of light, while soldiers and spectators cheered wildly to the men overhead. New machines, and new names, became famous during that week. Curtiss, the American, with his well-known biplane, was one of those who distinguished themselves; Lefebvre, who subsequently met his death while flying, was another. Farman, too, won the Grand Prix with an excellent flight of 112 miles, which feat did a great deal towards clearing the aeroplane of the imputation of being only a toy.

There followed a host of flying meetings organised on the Continent, and, later on, in England. Comte de Lambert made a daring flight from Juvisy, proceeding over the densely housed districts of Paris, and rounding the Eiffel Tower, before heading back to his starting place. Then came flight after flight, new records being broken as soon as they were made.

In 1910 a regrettable accident took place, Léon Delagrange being killed while flying in a cross-Channel type Blériot monoplane. To spec-

tators it seemed that one wing of the machine buckled and collapsed, the whole affair thereupon crashing to the ground, but the exact cause of the disaster was never ascertained. The name of Delagrange is one of the most honoured on the roll of aerial martyrs, for his pioneer work was of the finest description.

Aeroplanists began to attempt altitude flights, too, and it was now evident that the machines had come to stay. Aeroplane papers made their appearance in Europe and America, enterprising firms set up aeroplane workshops, engineers set to work at the building of aerial engines, flying grounds were planned, and competitions organised. In a word, the flying age had dawned.

All the struggling through the dark ages, the dreams of monks and alchemists, the toiling of Victorian inventors, the planning and calculation—all this had marked the long road to progress, which had now reached the goal of success. Henceforth it was only a matter of improvement. Flight was possible; and straightway the military authorities of Europe began to turn their eyes towards the aeroplane.

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CHAPTER X

Aerodynamics and the Mysteries of the Air

BEFORE dealing with the aeroplane, as we know it now, and with flying in modern times, it is necessary to make some reference to the air in which the aeroplane flies. In just the same way shipbuilders and navigators find it necessary to study the currents of the ocean, and all those outwardly invisible movements of water that have such great bearings on navigation, be it with a four-masted sailing ship or a 20,000-ton battleship.

To many of my readers the heading of this chapter may seem rather exaggerated. The average person will want to know what the mysteries of the air can be. "Of course," he says, "there are gales, and breezes, and cyclones; but still, we know something about those already. And if it is blowing too hard, there is no need for an airman to try and fly."

That is true. But it is not so much with those mysteries, which can be dealt with more or less by the Weather Office, that we have to deal, as with certain other problems—the problems of the "navigation" of a heavier-than-air machine, which, as you probably know, form a science by themselves. That is the science of aerodynamics—and a very deep science it is.

The science of aerostatics deals with the problems presented by a body lighter than air floating in it. It pertains to balloons. Aerodynamics, on the other hand, considers aeroplanes —actual flying machines. As I have stated, it is a deep science, and one of modern development. It is a science where the mathematical engineer and the man who is fond of dealing with involved figures and formulæ are in their element.

There is an endless variety of points to be considered in connection with the aeroplane's behaviour, and those useful gentlemen, *x* and *y*, who do such surprising and often disconcerting things in algebraic calculations, are given plenty of work in helping to solve the mysteries of the air. They are continually cropping up, for there are a good many "unknown quantities" in aerodynamics, and should any of my readers desire to see the way in which these mysteries are investigated, they have only to consult one of the numerous text-books on animal or artificial flight. If they have a taste for figures, they will be much edified.

From mathematical text-book to the complete aeroplane—that is the course which aerodynamics lays down for the intending inventor. And when you next witness a flight, finishing with a *vol plané*, it may interest you to remember that it was made possible largely by calculations!

Of course, I do not mean to say that practical experiments have not contributed their share to the work. They have probably had more than their share, and without them little could have

been done. You have already seen something of the way in which these experiments were conducted in the chapter on gliding, and there are other tests and trials, which will be mentioned in connection with the aeroplane. In many cases these trials have only revealed new mysteries for the men of figures to puzzle over; but practical work is always necessary to prove theories.

You may study the mathematics of a cricket ball in flight, and learn all the mysteries of spin and break. But you will have to practise first before you can take a good batsman's off stump out of the ground. Still, the instructions you may have read will prevent you from stumbling along blindly in the hope of discovering the right way to get "work" on the ball, and in the same way aerodynamics will show the aeroplane builder something of the correct way to construct his machine, and do away with the necessity of his running up scores of failures in the hope of stumbling on a successful type.

That is why aerodynamics is of importance to flying men. In time the science will show us how to make the best machine. As knowledge grows, it will tell us where to place our engine to get the best results, what type of propeller is the most efficient and what shape of plane will give most help.

Now the first question which arises in the mind when the aeroplane is considered, is probably, "Why does it fly at all?"

That sounds a simple question, and may be received with scorn by my readers. But if they

will pause a moment they may realise that it is not quite so easy to answer as they might imagine. Why should this machine, which is very often of considerable weight, rise so easily, and sail at giddy heights, bearing a human driver? There is no doubt that if an equivalent weight of lead, or wood planks, or furniture, or anything you like, were cast from an elevation, it would fall at once. The shape, then, of the aeroplane is one of the first things that makes flight possible.

The first simple thing to consider, in getting some idea of the reasons of flight, is the kite. To all intents and purposes the kite, of whatever shape you like, is an aeroplane. And the pull of the string fastened to it represents the driving power of the motor on the real machine. "The angle of reflection is equal to the angle of incidence." I expect many of you have heard that truth before. Put simply, it means that if an object strikes a surface at any angle, it will "bounce back," as it were, at the same angle at which it struck.

Thus, if we tilt the flat side of a kite against the wind, the air-current strikes it, and is reflected downwards, at a similar angle. And the line bisecting that angle represents the upward thrust obtained. In a free kite this upward thrust would ordinarily blow the plane back, but the pull of the string prevents this, and it is therefore kept soaring. The method of starting by towing it behind you makes the kite still more like an aeroplane; for there you have the plane driven, or, at any rate, pulled through the

air, at a certain angle, until its speed is sufficient to allow it to rise, and it is then kept up by constant tugs.

This, then, is one of the simplest truths in connection with flight; and for the moment we must consider other points in connection with the aeroplane.

We are so accustomed to walking in the air that we do not remember, as a rule, that it offers much resistance. We scarcely know that it exists, until we are facing a strong gale and can feel the force of the wind. But it is very soon borne upon the airman that the air offers a strong resistance to his machine; in other words, the passage of his machine through the air sets up considerable friction. To airmen this friction is known as "skin friction."

If, when you have been in a moving boat, you have dipped your hand into the water, you must have noticed the resistance it occasioned. And you must understand that exactly the same truth holds good in connection with the aeroplane—every irregularity or protuberance on its surface in some way hinders the free passage of the air. This, of course, hinders the machine, just as it slows a boat.

It is one of the aims of the builder to discover the shape of plane and aeroplane which will best do away with this resistance. This is done in many ways, and great care is taken in some modern machines to overcome every form of skin friction. For instance, it is known that currents of air and currents of water move in what are

known as "stream-lines." They flow in regular paths, without eddies or whirlpools. The disturbance of this stream-line by any projection which sets up whirls causes hindrance to a body passing through the air, and therefore planes and spars should be shaped to allow the air to flow easily past and over them. In this connection we can take a lesson from Nature by studying the form of fishes. The fish seems to be specially shaped to avoid undue resistance to stream-line, and on some aeroplanes the spars are curved, and their sides planed down, to represent as nearly as possible the form of a fish. They come to a sharp edge in front and rear, while bulging in the centre. They are carefully varnished, too, to make them "slippery" as it were, and the same care is taken with the planes. With their shape I will deal in a minute.

These points may seem unnecessary. But it must be remembered that the aeroplane is a delicate machine, and trivial defects—as they seem to the ignorant—may produce results which seem disproportionate.

The flying machine has to face varying air-currents. They are invisible, but they are there, blowing this way and that in streams and rivers—just as the currents flow in an ocean. If the aeroplane is to be a success, it must be constructed on the best lines for meeting these currents.

Let any one of my readers imagine for the moment that he is about to design an aeroplane without any knowledge of aerodynamics or "air mysteries" to help him. How would you, for

instance, set about the task? Well, the first thing, I suppose, would be to take pen and paper and drawing instruments, and think! You must remember that it is no use piling on your planes anyhow, putting a flat plane here and another there, and adding an engine on chance of discovering the right balance and lifting power.

That method might hold good with a paper glider, or even with a crude elastic-driven model, meant to fly a few feet in still air. But your big machine is to carry human beings in strong breezes—almost gales—and to bear all the weight of the engine besides. If you make any mistakes, life may be sacrificed.

So having provided yourself with your instruments, you sit down, and draw, perhaps, a plane. Quite simple—but will your plane give any support at all? Have you made it the right shape, to start with? Flat planes look rather effective, you may think—but are they of any use? The question wants answering, and aerodynamics will show you how to answer it. One of the first things you may note is, for instance, that your planes should not be flat, but curved in a particular way.

It was in 1883 that Horatio Phillips was experimenting in this direction, and as a result of his work he found that the best form of plane was a cambered, or curved, surface. The plane is arched from front to rear, the highest part of the arch, the hump, as it were, being considerably nearer the front edge, the plane sweeping back in a long, gentle slope to the back edge. The

plane is also thickened in front, at the hump, and tapers away finely. It is built, in fact, on the lines of a bird's wing, and is undoubtedly the best form of plane invented so far.

Maxim, as well as Phillips, experimented with this form of plane, by suspending it in special pipes in which draughts were induced, and testing its lifting power. These pipes are known as "wind tunnels," and are of the greatest importance in making lifting tests in this way. A number of them are installed at the National Physical Laboratory at Teddington, where various trials and experiments relating to air-machines are carried out.

Thus it was found that this humped form of plane possessed the greatest lifting power, and inquiries were then made into the reason for this result. Opinions differed on the subject, but the generally accepted theory is that the air current strikes the upper part of the hump, and is then reflected at an acute angle upwards away from the plane. This produces a partial vacuum above the rear sloping portion, and, as it were, sucks the plane up, thus giving it some power of lifting.

At the same time the air which strikes the underneath portion of the plane is cushioned under the arch, and runs down clearly to the tapering back-edge, and it is this air, which the plane, driven along at high speed, catches and forces down beneath it, that gives the main support.

The planes, then, provide the supporting surface, and in form, or section, they should be humped. As to their actual shape there are many differences

of opinion. Phillips considered that all that mattered was the width of the plane in front, or, as it is called, the length of the "entering edge." He did not pay much attention to the shaping of the sides of his planes. Other authorities have insisted that the aeroplane must be rectangular, as is the case in modern machines as a general rule. Some designers keep the front edges of their planes of the same thickness. Some taper them off at either side—and all of them get good results. So that it has yet to be decided which is the perfect *shape* of plane, as apart from section.

In the case of the supporting surfaces, again, opinions are divided. The triplane, the biplane, and the monoplane are examples of different methods of disposing the supporting surfaces. In the case of a monoplane and a biplane, if you have two machines of equal width, it is obvious that the biplane, such as the Wright, has double the supporting surface of the monoplane, owing to the fact that it has two supporting surfaces, one above the other.

Now all machines must run at a certain speed on the ground before they develop enough lift to raise their engine and passengers. At a certain speed they will lift so many pounds for every square foot of supporting surface. So that a biplane of the same weight as a monoplane, and the same width, as it has double the supporting surface, will start flying at a much lower speed. The same truth holds good in the air, for if the area of the planes is reduced, the machine must fly faster, in order that the planes may catch and

push down sufficient air to support it. Small supporting surface, high speeds, is the lesson that aerodynamics shows us here. And if you wish your machine to be a very fast flyer, you must construct it so that it will be also a fast land-traveller, for otherwise it will not be able to run fast enough to get the required lift before leaving the earth.

I expect a critical reader may here object on the grounds that I have omitted to mention the different horse-power of the engines that might be employed. He will want to know why the builder cannot put a much more powerful engine on his biplane, and so rise at a low speed, and fly as fast as he likes when he is in the air. The reason is that all aeroplanes appear to have a certain maximum speed, which they cannot exceed, however powerful their engines. So that if an airman is flying in a machine which can only reach the fifty mile an hour limit, and finds that his engine has still a reserve, he cannot increase his speed by letting his engine all out. For if he does that, instead of flying at sixty miles an hour, he will merely keep at the same speed and rise higher. The extra power sends him up, instead of in a horizontal direction. All very well for an altitude flight, but not much use for a point-to-point race!

As a matter of fact, at the time of writing, there is a rumour afoot that a machine is being built by an English airman with a variable plane. It will show a large supporting surface at the start—rising at a comparatively low speed—and then, when high up, will reduce the area of its

plane, and, as a consequence, must fly faster. It remains to be seen whether the rumour is correct, for there are considerable difficulties in the way of building such an aeroplane.

You will see, then, from this elementary sketch, that designing an aeroplane with any knowledge of its probable behaviour in the air, or of its requirements, is very risky work. It is like going about the world blindfolded.

But even when you have learnt something about planes, when you have decided that they must be humped, and may be rectangular, and that they must be disposed in a certain way ; and when you have calculated their supporting surface, and made sure that they will be able to lift your machine, even then you are only at the beginning of your work.

Taking your planes as designed, where are you going to put your weight—all the dead weight of engine and framework or fuselage ? Obviously, if your machine is wrongly balanced, something unpleasant, and sudden, is going to happen when you are in the air !

There are two vitally important " mysteries " to be considered here—the centre of gravity and the centre of pressure. If you place your engine so that the centre of gravity comes too far back, then, if your plane is tilted at a big angle, so that the pressure centre slides towards its back edge, as it might do when soaring, your aeroplane will take the opportunity of dropping backwards like a rocket stick, towards Mother Earth. On the other hand, if you put the weight too far forward, and start

to descend with a *vol plané*, the aeroplane will dive downward, like a badly made paper dart, instead of gliding quietly to land. And it must be borne in mind, too, that as you fly faster, the angle at which your planes are set to the wind decreases; they may come down more nearly to the horizontal, and the pressure centre then approaches close to the front edge. Here again, if the centre of gravity is far up, down comes the machine!

Without going further into this question, however, let us imagine that you have solved these difficulties, and have settled on the position of engine and the disposal of the weight in your fuselage.

Next comes the important question of lateral stability—the "sideways" balancing of the aeroplane. This, as you probably know, is performed by small movable planes, known as ailerons, or balancers, or by the device of warping. It is obviously essential to have some contrivance to ensure that your machine will not dive sideways when it rolls. Were it not for some provision to prevent this calamity, it would be impossible for you to bring your aeroplane round in any turn for the following reason:

When you operate the rudder that gives you lateral steering, the aeroplane begins to pivot round, more or less, on the inner end of the plane. The outer plane swings round like a stone on a string, at a higher speed than the inner plane. As a result it rises higher and the aeroplane tips, or banks over. It leans inward, as a cyclist does when rounding a corner. The faster and sharper

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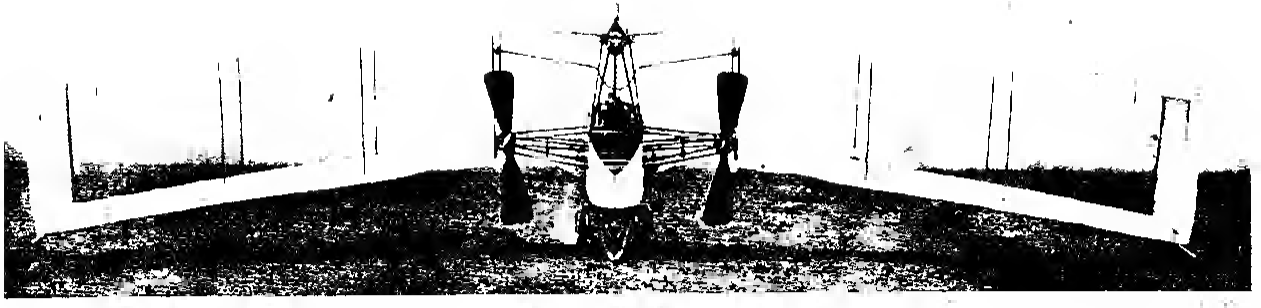
is the turn, the steeper becomes the angle, and eventually it would become so steep that the aeroplane would simply slide down to destruction. Warping and other contrivances are employed to prevent this possibility. When the machine is turning, the tips of the wings on the inner side are turned up, presenting a bigger angle to the air than before, while those on the outer, raised side are turned down, showing a smaller angle. In other words, the resistance is greatly increased on the inside of the curve and decreased on the outer edge, and the aeroplane thus only tips up to some slight degree, so that the danger of slipping is ordinarily done away with. The balancers are employed in exactly the same way, of course, in the case of a machine rolling, or caught by a gust which looks like tipping it to a greater angle than is comfortable.

As a matter of fact, in turning, some flyers use a manœuvre almost exactly the opposite to that which I have described. They warp the outer plane up, and thus increase the angle at which the machine is banking, and trust to the centrifugal force at high speed to keep them in the air. It must be noticed that even with ailerons in action an aeroplane will sometimes bank over to a certain extent. It thus shows a smaller supporting surface to the air, and may drop a little, and if this should happen when it is flying just above ground an impromptu smash may be the result.

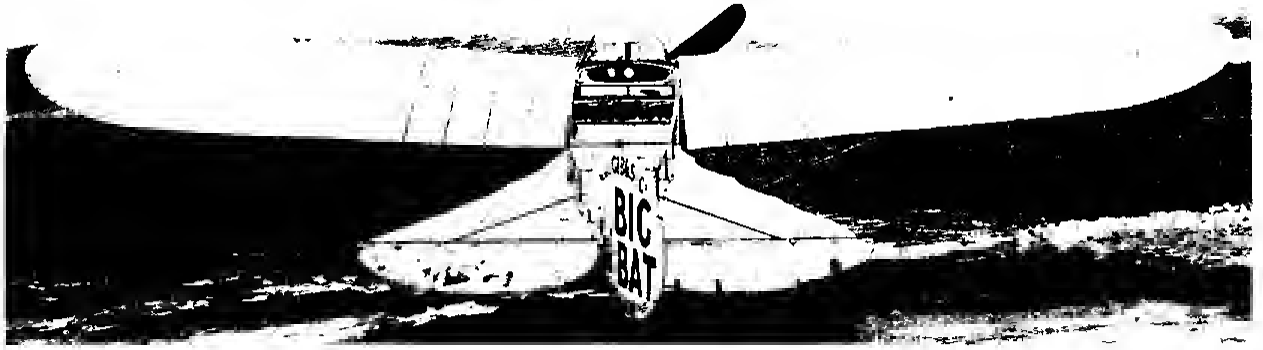
If once the question of this lateral stability can be solved with certainty by automatic means,

much of the trouble of the airman will vanish. As it is, he has to be continually on the alert to overcome the rolling of the aeroplane, which is greater with some types than with others. One or two machines are undoubtedly very stable, notably the Dunne aeroplane, which is a V-shaped biplane of peculiar design. Of this machine much is to be expected, for its inventor has frequently managed to fly for comparatively long distances with both hands off the controls, and the control levers locked into position. At the risk of its seeming out of place in this chapter, I take the liberty of quoting the following passages from the pages of the well-known aeronautical weekly, *Flight*, in connection with the Dunne machine. The occasion was one of an extended trial of the Dunne aeroplane, and Mr. Dunne is telling his experiences:

"The first thing to do was to show that the machine could fly as well and strongly as those of ordinary T-shape, to exhibit the power of control and manœuvre given by the two little steering-flaps, and, above all, to show that with this type of machine good turns, with the correct amount of banking and no side-slipping, could be effected without recourse to the complicated 'three rudder' system. . . . It is a well-known rule of flying that, before throttling the engine, the machine's bow should be pointed slightly downwards to avoid the loss of speed that would otherwise ensue, and it is in the proper manipulation of the levers immediately afterwards, to maintain speed and keep the machine



The Dunne Biplane



Blériot Two-Seater Monoplane

under control, that the trained aviator has to exercise his greatest skill. To throttle without first depressing the bow, and then leave the machine severely alone, is a stiff test of longitudinal automatic stability, though, of course, no test of lateral stability.

"So both in this flight and in the second I first locked the levers in the central position in which they are left while flying, then throttled, and immediately threw up my arms and left the machine to come down from the flying tilt to the gliding tilt of its own accord, and thence find its way earthward.

"The next point was to prove the safety of the machine. As we have no place for passengers in the present apparatus, I suggested that I should go round the same short circuit and carry out the writing test. I proposed this, as I know of nothing else which so thoroughly puts to proof the aviator's real trust in his machine's fitness to look after itself, compelling, as it does, absolute detachment of mind. I ran down across the wind . . . and began to rise steadily. As soon as I saw that I would clear the bushes on the boundary dyke, I locked the levers and felt for the paper and pencil. . . . The paper was in one pocket and the pencil in another. By the time I had got them ready I must have flown a considerable distance. I started to set down certain points that I was anxious to remember. First I counted the figures on the revolution indicator, which has no figures between the 1,000 and 1,500 marks. . . . I then observed the position of the

levers relatively in the toothed racks, and made a note of that. I next looked about inside the boat for something else to note, and while doing so became aware of the violent wind in my face, which, curiously enough, I had entirely failed to notice on the previous flight.

"From the time I had first locked the levers until now I had not paid the smallest attention to what the machine was doing or where it was going. It had been left to follow its own fancy, and might, by this time, be anywhere or in any position, for all I knew. However, looking up, I saw that it was still level, but had drifted down wind, and was aiming to hit a wind pump, so I decided to commence the turn.

"I separated the levers, holding them till the turn had started, noted its radius, which was shorter than I required, diminished the difference between the lever positions, locked them, waited a little while with hands off, until I was satisfied with the radius of the turn and with the rapidity with which the machine was mounting, got hold of my paper again, and, with some difficulty, wrote, 'Turning now.' Looking over the port bow, I saw a farmhouse nearly beneath me, and, realising that the circle was now bigger than I had intended, and also that I was much higher than I thought, I pushed each lever into the fourth notch, and, sitting with my hands in my lap, allowed the machine to swing itself sharply round. . . . I saw that I should have to descend at once if I meant to get back to my starting-point, so I moved the machine's nose a

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degree or two round, aiming at the point in question, returned each lever carefully to its central notch, throttled the engine, and held up my arm. Instantly the machine's head drooped a little, and, without any abatement of forward speed, she began to sink towards the ground."

I have quoted this at length, because it gives a good impression of the way in which an airman has to watch the behaviour of his machine, and of how his time is taken up in control work in an ordinary machine. Undoubtedly Mr. Dunne's machine does away with much of the airman's worry, and may have important bearings on the development of the stability machine. Automatic stability is also being sought by other means, and a firm known as Planes Ltd. are experimenting with a machine containing a pendulum, the swing of which is intended to counteract any undesired dipping or rolling, while, at the time of writing, there is a rumour that the Wright brothers have an invention in hand which makes automatic stability possible. These and similar trials will be watched with interest.

And now a few words about the air. Supposing that, after having conformed to all the known laws of aerodynamics, you have constructed your aeroplane, arranged as well as possible for lateral and longitudinal stability, and made sure of your planes and engines; you have varnished your fuselage and arranged, as far as possible, that skin friction shall not cause loss of power to your aeroplane, and now you are going to study the machine's behaviour in the air.

You start to run along the ground, preparatory to rising, and here we must stop for a moment's consideration. Always remember that there are two speeds to be noted in connection with a flying-machine—its land speed and its air speed. Its air speed is simply its speed in relation to the air in which it is flying, and not in any relation with the earth below.

So, if your machine will rise from the ground at twenty miles an hour, and you start it against a wind blowing at twenty-five miles an hour, it will drift backwards at five miles an hour in relation with the land. But its air speed is still twenty miles an hour. Let it turn with the wind and it will travel at a speed of twenty plus twenty-five miles—in other words, at forty-five miles an hour—and that again is only in relation to the land below. In excess of the wind it is only travelling at twenty miles an hour, and it must not go any slower, for then it will drop, since its minimum air speed is twenty miles. It will be forty-five miles an hour or nothing in this case!

As a matter of fact, it is difficult to rise at all with a strong wind behind the machine, because your aeroplane will have to run very fast before the planes can overhaul the air, so to speak, and force sufficient air beneath them to raise the machine. The question becomes more complicated when turning movements are being executed. If you are flying at five miles an hour, against a twenty-mile-an-hour wind, in a machine which lifts at twenty miles an hour, then, when you turn with the wind, your engine will have all its

work cut out to increase your speed; for, as you are flying in a twenty-mile-an-hour air current, your machine must actually increase its speed to forty miles an hour if it is to continue in the air—and that almost at once. Turning back into the wind requires equal care, unless undesired results are to be obtained.

All these points must duly be remembered, and you will begin to see that the position of the aeroplane pilot is not altogether so simple as it looks. I heard a man stating the other day that there was nothing in aeroplane management. He was not a pilot himself, by the way! He said that you merely sat there and steered, and kept your eyes open, and that the whole thing was far simpler than motor driving on a greasy road. Well, if that were the case, the perfect aeroplane must have arrived! The aeroplane pilot has to watch the winds, which, whatever the motor-driver says, seem to me to be more tricky than wet tram-lines and mud, though, of course, piloting becomes more or less a matter of instinct and habit after a time.

The behaviour of these air-currents themselves is decidedly capricious. What would the motorist say if, when driving over a beautifully level road, his machine suddenly plunged sideways into an invisible hole? He would probably be much upset, in two senses, and would blame the district councils for not marking the depression with scaffolding or red lamps.

Yet the pilot of the air has to deal with eventualities of almost similar description. There are what

are known as "pockets" in the air, produced by temperature or weather conditions, about which little is known. These pockets seem to be literally holes, where the air is less dense than in the surrounding atmosphere. An aeroplane, flying steadily along, comes across one of these unseen traps, and slips, forward or sideways, as the case may be, and unless the pilot is alert may dive too far to recover its balance. The American airman Hoxsey is said to have been killed owing to one of these pockets. He was coming down from a big altitude in a spiral *vol plané* when his machine slipped sideways, apparently running into one of these holes, the existence of which had been noted just previously by Latham on his Antoinette monoplane!

Then, in addition to such disconcerting things as holes, there are, of course, whirlwinds. At present very few aeroplanes will fly in anything approaching a gale, although Latham and various other airmen have flown in the face of very strong winds. Still, the aeroplane will probably be developed one day sufficiently to allow men to go up in anything short of a hurricane, and then they must keep their eyes open for whirlwinds. As I write this I read in the morning paper of an extraordinary incident which occurred during a stiff gale in England. A girl was suddenly caught up by a whirlwind, lifted to a height of twenty feet, and dashed down to the ground again, being so seriously injured that she was killed. Now, imagine what would happen if an aeroplane should run into such an aerial disturbance as that. There

is no doubt that it would be upset, capsized possibly, and its pilot hurled to death. Of course, this was an exceptional incident. But it is a good example of the tricks that air in motion can play, and of the ambushes that may lie in wait for the motor-driven machine that comes along with the gale like a wind-blown rook.

But calms have their surprises as well as gales. We, on solid earth, are not accustomed to consider the air as a great moving ocean, with its calms, and currents, and rapids, but experiments with gliders and aeroplanes have taught us a good deal in this direction during the past few years. A steady air current seems to follow the contour of the ground over which it is blowing, more or less. On the level it keeps steadily moving forward. On reaching a hill it is deflected upwards, and continues ascending in what are known as vertical columns for some distance above the hill's summit.

It then appears to descend into a valley, say, with a marked downward slope.

An aeroplanist, then, flying up a valley, has two points to consider. As he enters the valley and comes within range, as it were, of the hills, he may find his machine literally forced earthwards by air currents pouring on him from above. And, as he crosses the hills, he may find himself in an unexpected ascending stream, which will, perhaps, tilt his plane to an awkward angle. Air, too, which is heated in a valley under a very hot sun, will sometimes rise and give a strong air-current. The airman, noting this, may fly low. But on approaching the hills he is pretty certain

to find himself running into a very stiff downward draught, rushing to replace the rising air he has just crossed.

Many learned treatises have been written about these air mysteries, but there is undoubtedly a tremendous amount still remaining to be learnt. The exact behaviour of the air in a thunderstorm, say, is interesting from the airman's point of view; but it must be confessed that an aeroplane, with all its load of metal, would not be the most comfortable place in the world, were it flying just below sullen thunder packs, threatened not only with destruction from lightning, but also with harsh treatment from sudden tornadoes. Mr. Rudyard Kipling not long ago published a very fine aeroplane or airship story, which, though imaginative in the highest degree, gave a wonderful sketch of what might happen to the air and those cruising in it during a tornado with electrical disturbances. Some of you may have read it.

Well, I have tried to give you, in this chapter, some simple ideas of the elementary facts of aerodynamics, and of the difficulties with which the airman may meet owing to the strange ways of the air currents. As I have said, the subject is a deep and complicated one, and, of course, I have not touched upon very many points which are of more interest to the practical engineer than to the amateur reader—stresses and strains, the infinite variations caused by different propellers, and so forth. These points some of you may study, perhaps, later on, if any of you should

become engineers. The deeper questions of the air and its motions may be left to scientists.

But you will, at any rate, have gained some idea of the airman's problems during flight, and have learned something of the reasons of flight, of "how it is done." And, having done this, you are ready to consider, with more appreciation, the various modern machines that are flying every day, and to give more attention, perhaps, to the doings of the airmen than you have hitherto done, and more particularly, I hope, to the doings of British and Colonial airmen.

For the latter may one day gain command of the air, as Drake and his brother seamen gained the command of the sea, if only they are helped and appreciated as they should be. And now to flying-machines that have proved, or are proving, their worth.

CHAPTER XI

How an Aeroplane is Built

BEFORE we examine the finished aeroplane at close quarters it would be as well first to pay a visit to an aeroplane factory and view a modern machine in the making. My readers have seen, maybe, modern machines in full flight, gliding gracefully over the tree-tops. Now they are to see them in the rough—sketches, so to speak, for the finished pictures, future conquerors of the elements on the stocks.

By the courtesy of the managers of the Aeronautical Syndicate I was enabled to pay a visit to their workshop in the well-known flying-ground at Hendon, near the Welsh Harp, and I shall ask my readers now to accompany me there in imagination, and to watch the construction of the British monoplane, known as "The Valkyrie," a full description of which occurs in a subsequent chapter.

The sheds stand at the end of Collindale Avenue, Hendon, facing a great sweep of open land. You could not imagine more unpretentious buildings, plain wood erections, far less imposing than any locomotive workshop in appearance, and yet, to the person of imagination, far more romantic. In these workshops are hidden wonders undreamt of by the old engineers. There, behind

the rough exterior, lie the germs of a great epoch, and almost every day the birds in the hedges and trees round about are startled by the rattle of motor-engines and the whirr of propellers, driving over them, as a Grahame-White, a Blériot or a Valkyrie machine trails its shadow over the turf below.

Simplicity is again the keynote of the interiors of these workshops. You step in through an office which echoes to the click of the typewriter. On the way you notice certain unusual garments hanging to pegs on the walls; fur-lined coats, mittens, leather caps, and dark-brown overalls, the garb of the airmen. Then, passing through a small door, you find yourself in the main workshop.

The first impression that greets the visitor is a comprehensive one of sunlight and white wood shavings. The building is a lofty one, of great roominess, pierced by windows at one side, through which strike spokes of sunlight, crossed and recrossed by dancing and glittering dust specks. The floor is littered with shavings—curly shavings, and flakes, and splinters—and the air is full of tumultuous noise.

The grating of saws, the swish-swish of planes, the rapping of hammers and clink of iron all join in the song of the workshop, and from somewhere outside the purring of a motor drifts to the ear.

All around are lathes, tables and carpenters' benches, laden with tools and odd lengths of wood. Against the walls lean parts of an unfinished aeroplane—planes and spars, waiting to be fitted to a machine under construction.

Hanging in a looped rope is a great wooden propeller, the blade painted a dark blue, with a thin film of oil lying on it, and if you have seen little of aeroplanes at close quarters you will be astonished at its size. It looks clumsy and unwieldy; but on lifting it you find that it is surprisingly light.

Before you men pass and repass: carpenters in white aprons, with mallets and chisels; mechanics in brown, or blue, overalls, with oily hands, carrying, maybe, spanners, a petrol-tin, or a coil of bright wire. Looking farther afield you discover more petrol tins, buckets, brushes for varnish, and a number of spare wheels, with big tyres, some deflated and some drum-tight. To one side is a little group of men lifting from a packing-case a new engine that is shortly to drive the propeller on a racing machine. Then come more stacks of wood and pieces of greyish-brown cloth.

In the middle of it all stand the machines themselves, all those in this workshop being finished. Close at hand is the first British passenger-carrying monoplane—a three-seated machine. The main peculiarities of "The Valkyrie" will be described elsewhere, but even the non-technical visitor will probably be struck by its unusual appearance as it stands in the mottled sunlight and shadow.

It is large, and the first point that strikes the beholder is the size of its skids—like the skids of a big sleigh. From stern to bow, if we may use nautical terms, they sweep forward in a bold

curve, turning up to the elevator and the immovable fore-plane above, which projects in front of the pilot. The skids are distinctly solid in appearance, and the spars and brackets, which are built on to them to form the fuselage or framework, are thick and strong-looking. Between the spars, set in the midst of gleaming wires like a spider in its web, is the engine of shining copper—a Green engine, this—and before that are the three seats for the pilot and his passengers, some seven feet from the ground. Then, behind the engine, comes the propeller, and behind this again, stretching widely on either side, the bold sweep of the grey main planes, followed by twin vertical rudders, wired and braced beyond the stern of the fuselage.

Behind the machine, through wide doors, we catch a glimpse of open country, sloping fields, torn here and there by wheel-tracks, and fluttering red flags. Out there is the learner's monoplane, a smaller machine, of similar design to the big flyer before us, gleaming white in the sun. This, then, is the garage, and, turning to the left, we enter another shed to find machines that are at present very much in the rough.

The first thing to build, having made your plans, and proved them to be correct, by the successes of your early machines, is, of course, the fuselage or framework of your standard type of aeroplane. This skeleton must be built strongly, and fastened together with infinite care, for it will have to stand many strains—the weight of the engine and pilot, the wrenching of odd gusts of wind, and, above all, the shocks of starting and

landing on rough ground. The way the fuselage of a Valkyrie monoplane is built might, I think be copied by a model builder, if the model were large enough and built to scale.

The wood used in these machines is chiefly Honduras mahogany, a very tough timber of light weight, although for the racer spruce, being considerably lighter, is adopted. Other types of machines are built of pine and hickory, while bamboo has, at times, been adopted.

The plans having been prepared and verified, the floor of the workshop is cleared, and the designer and his assistants proceed to re-draw the plans of the fuselage in full size on the planks. This necessitates careful measurement and hard work, but it renders the subsequent labour of construction easier, the various parts of the machine being literally assembled over the plan, thus making it easy for the workmen to avoid mistakes.

When the plans are thus made ready the wood is chosen, and this is a particularly important part of the preliminary work, for, as I have pointed out, the fuselage has to stand big strains and stresses, and a flaw in the timber might mean sudden disaster at any time. Wood, indeed, is the most important material used in aeroplane construction, and a great deal depends on its quality. It stands to reason, therefore, that a wood which will bend easily will be unsuitable. But, all the same, the toughest woods have to be given certain cambers or curves in the framework, particularly in the case of the spars that form the skids. This is

accomplished, in the case of the Valkyrie machine, in the following way :

The spars, having been shaped down, are run into a long, narrow oven, where they are steamed until they are pliable. They are then drawn out and fastened to templates by holders, being bent by these to a curve exceeding that to which they are required to be brought in their final state. After this they are left for some time until dry, when they are lifted from the templates, and automatically spring back a little to the curve required. Spars of all kinds are treated in this way—heavy timber for the skids, or lighter woods for the ribs of the planes.

The skids being ready, they are laid over the plan, and various other supporting spars forming the framework are fastened to them by means of metal brackets. These brackets, in the "Valkyrie," are made of a special mineral alloy, as light as commercial aluminium, and almost as strong as steel, for pure aluminium joints bend and break rather too easily for aeroplane work, and steel, although able to stand all kinds of strain, is too heavy.

Considerable care, too, has to be given to the straight spars which are bolted into the frame. In the early Wright machines the workmanship was very rough, the spars being left in a more or less unfinished state ; but in modern machines such conditions are not permitted. "Skin friction," about which you have read something in the chapter on aerial mysteries, is not to be disregarded nowadays, and the spars are, therefore,

most carefully shaped to "stream-line form," and planed and varnished till they are as smooth as glass. Also, as it is well known that a stick generally breaks in the middle, they are thickened to a gentle bulge in the centre, so that the strain required to break them has to be unusually great.

The rough framework, being bolted together, is then braced at various points by strong wires, tightened by wire-strainers, nuts and screws. In the "Valkyrie" as few wires as possible are allowed to bend at any point. The thick end of the wire is pared down to a screw thread, and the nut screwed on to it above the spar to which it is fastened. In many other machines the wires are bent freely, and are therefore more liable to slip from time to time, making a good deal of "tuning up" necessary before each flight.

The skids having been thus built up, a further skid-spar, already cambered, is placed along the bottom, cramped into position round the first skid, inch by inch, and fastened and bound with copper wire so firmly that the two skids are to all intents and purposes one spar. When this is done the skids will bear at their centre a suspended weight of one ton without breaking, and they are then ready to be placed on the stocks.

These stocks are like ship's stocks—four blocks of wood fastened to the floor, with V-shaped notches cut in them, in which the skids rest, two blocks supporting each skid. On these the aeroplane begins to take shape. The two sides of the fuselage are now completed, and they must be joined by the cross spars, which will bear the motor

and the pilot's seat. For this purpose more stout spars, brackets and wires are employed.

Meanwhile, during the progress of the fuselage, the plane-makers have not been idle. The planes are exceedingly difficult to construct satisfactorily, for many reasons. In the first place they have, as we know, to support the entire weight of the machine in the air, and they must therefore be strong. At the same time they must be, to some extent, flexible, in order that any shocks sustained in landing shall not snap them like rotten sticks. Yet again they must not be so flexible that air pressure and the buffeting of the winds, when the machine is in flight, will change their camber.

An aeroplane maker's life, you see, has very little jam in it. If he makes his planes too rigid he will have to use all his spare cash for repairs after each flight. If he makes them too flexible he will have to use it for surgeon's fees, should he escape with his life! So that he has to be very careful to find the happy medium which will give him safety and strength at one and the same time.

Looking round the workshop, we discover the way in which this is done. In one corner, leaning against the wall, is a big rectangular framework of white wood, crossed by a number of thin ribs. This is the skeleton of a main plane, and on inspection we find that it is delicately cambered. The front edge is thickened, and the ribs rise in a gentle slope for some inches, till they reach their maximum curve, when they descend again, in a very much longer slope, to the back of the plane, where they are firmly fastened to the main spars.

The necessary camber has already been given to the ribs in the steam box already described, and when once they are fastened satisfactorily the planes are ready for covering with fabric, which in this case is simply cloth, vulcanised with rubber solution.

The fabric is nailed to the front edge of the plane, and then stretched tightly over the ribs and nailed again, the greatest care being taken to produce a uniform tightness. Over each of the ribs a further long strip of fabric is fastened with rubber solution, and when dry the plane, now beautifully smooth and curved, is ready for business. Rudders, small elevating planes and ailerons are all treated similarly, and by the time they are finished the fuselage is ready to receive them.

It has now been braced up by wires, and the spars are firmly bracketed. As a matter of fact, in some machines a method of joining, known as " Ader's method," is pursued. In this method the spars, having been tied to metal rods laid over templates, are simply assembled by being bound very tightly by glued fabric-strips at the joints, much as a bat is bound after a mishap at net practice. And some airship fuselages of the torpedo shape are built in this fashion. But brackets are generally found to answer the purpose best, and they certainly give the machine a smarter and more trustworthy appearance.

The main planes are now lifted into position and fastened, and then the wire stays are added, and strained until they are perfectly taut all the way round. The little fixed fore-plane above the

skids follows, and the pilot's seat having been mounted in front of the supporting framework reserved for the engine, the movable planes—the balancers at the corners of the main planes, the double rudders, and the front elevator—are fitted, and the control wires taken back to the pilot's seat to be connected up with the levers and foot-rest.

This done, the aeroplane is all but finished. She lacks but the centre which is to give her life—the most expensive centre of all; and when the engine is bolted securely into position, and the propeller fixed, she is all but ready to brave the elements, and chase the swallows in their own blue sky.

Of the building of the engine it is not for me to speak here. It is a thing apart from aeroplane construction, and one of the things which strikes one most at an aeroplane workshop is the absence of "engineering appliances," those forges, furnaces, steam hammers, presses and mighty lathes which go to the making of the land flyer, the express locomotive. It is for the motor manufacturer to make the engine, and for the airman to mount it in a successful machine.

But when we come to propellers the case is different, for the airman can manufacture his own screws, and he has various methods of doing it. As a general rule propellers are of wood. Metal propellers are heavy and very easily bent, and at the same time, when revolving at a very high speed, they are liable to vibrate tremendously. Complex mathematical calculations show that this flutter

has a considerable effect in decreasing or damping the power of the screw. Wood, therefore, is found to be the best material for aeroplane propellers.

Sometimes the propeller is carved out of a solid block, and carefully planed down to the required shape. It is then steamed and keyed down to templates to give it the required "twist." Another very ingenious method is that of building it in sections, like a half-opened lady's fan. One thin section is laid above another, each section a little farther back from the one below it. The raw edges are then shaved down until the face of the blade is smooth, and the sections are fastened securely into position by being soaked in insoluble glue, becoming one single propeller.

This method is very difficult, and there is always a risk of failure attaching to it. In "The Valkyrie" the propeller is shaped from a solid block.

The engine and propeller being mounted, and the tyred wheels, with their shock absorbers of springs and rubber, fixed below the skids, the machine is practically ready for flight. A coat of varnish and a final overhaul, and it can be brought out of the workshop. If it is built according to the standard of a machine already successful, there is no fear that it will require any serious alteration. It should fly at the first attempt, and generally does.

My readers should understand that I have only shown them the building of an aeroplane from plans which are already known to be trustworthy.

But when a novel design is to be attempted,

the process becomes a great deal more complicated, for in this case a vast amount of time and calculation has to be spent upon the plans of the machine. The sustaining power of the planes, the horse-power of the motor, the weight to be carried, the thrust of the propeller—a very difficult point to find—the design of the planes, and their disposal; all these points have to be considered if the machine is to have a chance of success, and is to be able to hold its own with the fine standard types already flying.

An aeroplane is a scientific machine, built on exact and scientific lines, and according to the intricate laws of aerodynamics. A builder cannot throw wings and planes together at haphazard. Neither can he design a machine solely to please the eye by its graceful appearance. The old Voisin machines were good flyers, but they were scarcely beautiful. The Wright machine is probably one of the prettiest of the biplanes, but it is very certain that the Wrights had no thought of making it handsome when they designed it. They wanted results, and we know that they got what they wanted.

In this chapter I have tried to show you how the results are attained, and how, from its recipe of wood, wire and cloth, the aeroplane is built up. Of course, different details of manufacture are followed in the building of different types, but the same general principles apply in all aeroplane building.

You can order your aeroplane on one day, and three or four weeks later it can be drawn from its

shed, run on to the green turf, and then to the song of the engine it will rise to greet the winds that it has been made to conquer.

Such is the building of an aeroplane—neat and swift. Among the "extras" which may be said to add to the machine's appearance are metal polish, varnish, paint, upholstering to the seats and a name painted in sharp black letters on the planes. Add to these a compass, a map, an electric light bulb, hot flask, First Aid outfit in case of accidents, and provision basket, and you have the modern aeroplane, a thing of shining wires and snowy planes, ready to carry you easily and swiftly over the heads of your less fortunate brethren.

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CHAPTER XII

Some Foreign Aeroplanes

In describing the modern aeroplane, the writer has one considerable difficulty to face—the difficulty caused by the rapidity of modern progress. The aeroplane, no matter of what type, is constantly undergoing alterations. From day to day improvements are made in it, so uncertain is our present knowledge of flight. Sometimes these alterations are trivial; sometimes they result in a great change in the outward appearance of the machine. A description of the earlier Voisin biplanes, for instance, would not altogether apply to the Voisin of to-day, and the same difficulty applies in a greater or lesser degree to many other types of aeroplane.

Nevertheless, in all machines the main standard lines remain as a general rule, and it is necessary to treat the aeroplane as belonging to a type rather than to describe each machine in detail, if a correct impression is to be given.

As is the case with airships, aeroplanes have fallen into certain standard types, and in the main most of the "odd" machines follow, more or less, the lines of the better known aeroplanes, and can be described as belonging to the "Farman type" or the "Blériot type," or any other of the well-known standard aeroplane divisions. In

this chapter, therefore, I shall deal only with the better known standard machines, leaving most of the many other aeroplanes alone.

At the present moment there is a vast number of aeroplanes in existence in Europe and America, of varying merit and appearance. In addition to the many machines built by the standard firms, there are scores of aeroplanes constructed by private inventors, some of which have never left the ground, while others have made good flights, amply justifying the care and money spent upon them. France in particular can boast of an imposing array of machines of every description, and there seems to be no end to the fertility of invention displayed by our neighbours across the Channel. But despite the number of machines the standard types still hold their own, and when a great flight is made, it is generally performed in an aeroplane which has proved its worth in the past. To these machines, therefore, must attention be chiefly paid.

My readers are doubtless aware that aeroplanes fall, as a general rule, into two main divisions—monoplanes and biplanes. The monoplane, as its name implies, is a single-surface machine, carrying only one set of planes, and in general appearance not unlike a bird, or a dragon-fly. The biplane has two sets of supporting surfaces, arranged one above the other, giving it a bigger area of plane, width for width, than is carried by the single-surface machine. Both types have their ardent supporters, and it is a point for argument as to which is the better and safer. As

a general rule, it may be said that the monoplane is the faster machine, but this does not always apply, some of the smaller biplanes having a very good turn of speed.

In addition to planes, both types of flyer must embody certain other essential features, varying greatly in design in the different standard makes. Such features are the balancing contrivances, the rudder, the tail, and the elevator—a movable small plane, used for giving vertical, that is up and down, steering. It is in these details that many of the standard types differ so greatly, and in one or two machines almost the only difference that the casual spectator will observe is in the tail, or the rudder, although closer inspection would show other variations in the fuselage, as a rule.

Ailerons or balancers are employed, as I have mentioned in the chapter on aerodynamics, to increase the resistance on either side of a tilting aeroplane, and thus bring it to the horizontal position again. In some machines the wings are warped for this purpose, and balancers are not used. In other types the balancers are fixed in varying positions, are controlled by different movements, and are of differing shape. The same points apply to the elevators; while rudders have many peculiarities of their own. Great differences also occur in the fuselage and in the arrangements of skids and wheels. Engines, of course, fall into divisions of their own, and no type of engine is peculiar to any standard type of aeroplane. The term "Blériot-Gnome" or

"Blériot-Anzani" simply means a Blériot type aeroplane driven by a Gnome or Anzani engine.

It is, then, with the monoplanes that I must deal first; and it must be remembered that in this chapter I am only including foreign machines, as I think that a special chapter should be reserved for the various British aeroplanes now in existence.

The best known, and certainly one of the most efficient monoplanes, is the famous Blériot machine. I expect that many of my readers must be familiar with the appearance of this machine, which in flight is certainly one of the most picturesque of the aeroplanes, resembling some great dragon fly, or insect, skimming aloft with wide-spread wings. Most of the Blériot type machines are at present of comparatively small dimensions, the planes being rounded at the corners, and the tail and rudder being carried at the back of a girder projecting towards the stern from the pilot's seat between the two wings.

The most popular model of the Blériot machine is the famous Blériot XI class—the cross-Channel monoplane, in type very similar to that used by its inventor on his famous trip over the Channel, to which reference has been made elsewhere. The original XI was quite a small machine, the spread of the wings only amounting to 25 feet 6 inches, but it was exceedingly neat in appearance.

The fuselage was of the standard Blériot pattern, consisting of a long, four-sided wooden girder, tapering slightly from front to rear, where it loses its quadrangular form and comes to a peak or triangle. It was supported in bow and stern

by three bicycle pattern wheels, fitted with shock absorbers in the form of metal springs—two wheels beneath the pilot's seat, and one just in front of the rudder in the rear.

In the fore part of the fuselage the pilot's seat was enclosed by fabric laid along the sides of the girder, and on either side of this space the planes projected, cambered in the usual fashion, with the corners rounded off. They were smoothly covered with rubbered cloth fabric, and were fitted with a warping arrangement for assisting the balancing of the machine in flight. For convenience of packing or transport, they could be detached from the body of the aeroplane. They were braced by strong wires. In the original XI the wires bracing the planes from the top side were carried from two triangular frames erected at the pilot's seat and joined at their apices by a cross-bar.

At the stern end of the girder was a single vertical rudder to give horizontal steering; and in this rudder, as in the planes, the edges or corners were rounded. Just forward of the rudder, and fixed beneath the girder, was a tail, consisting of one single horizontal plane, with one movable, horizontal rudder or "flap" at either side of it. At the bow of the machine was the motor, driving a two-bladed wooden propeller mounted in front of the main planes.

Such was the Blériot standard type machine, but in later models some of the details have been altered and improved. In order to lessen resistance when travelling at high speed, the engine

is completely covered in by a metal bonnet, somewhat similar to that used on a racing motor, and the appearance of the machine is undoubtedly enhanced by this addition. Then, too, instead of the double triangular frameworks originally used for supporting the wires that braced the planes, a single triangle is substituted, situated in the very bow of the machine, from the apex of which the wires radiate to the various positions on the wings. Another alteration is seen in the stern, where the back wheel is done away with, two crossed hoops or skids being substituted for protecting and supporting the rear end of the girder.

In addition, the luxury of flying has begun to make its appearance in the matter of fittings and upholstering. The bucket seat for the pilot is cosily padded, and before it is a desk, holding a map, mounted on rollers, so that the airman can unfold his route as he flies; he is also provided with a compass and an aneroid barometer, while a case of repairing tools and a clock complete the outfit. On the whole, when every scrap of metalwork is nicely polished, and the machine is in its usual coat of snowy white, there is no prettier aeroplane in existence than the up-to-date Blériot XI type.

The Blériot two-seater military type aeroplane, which was exhibited at the last Olympia Exhibition, is also a picturesque machine. Its general lines are similar to those of the XI model of the latest pattern; but wind resistance is specially provided for by the covering in of the

whole of the fuselage with fabric, instead of only the bow, while the sides of the girder taper very thinly, in order that the effects of side gusts of wind may be reduced. The passenger seat is situated beside the pilot's place in rear of the engine bonnet, and the desk holding the map, compass and note-book is fixed to a slide, so that it can be moved from side to side before either pilot or passenger. The back of the machine rather suggests the shape of a pigeon's tail. The single horizontal tail, with the two elevators on either side, is done away with, and in its place the horizontal plane broadens out in a V-shape, like the tail of a bird, and the movable elevator flap—a rounded, almost semicircular plane—is fixed at the back end of it, forming the very stern of the aeroplane. As before, the vertical rudder is carried above the tail. This type of tail was found very efficient on various later Blériot models, and it gives the aeroplane a very bird-like appearance in mid-air.

These two machines are, of course, not the only types of Blériot monoplane. From time to time there have been a good many variations built, one of which, at least, bears very little resemblance to the typical Blériot XI type, which is the favourite machine of the series. This strange-looking aeroplane was the Blériot 4-seater, which attracted considerable attention at the time of its first appearance. The single plane surface exists as before, but the wings are fitted with big balancers—hinged flaps at the outside rear edges. The engine and propeller are placed

on a level with the planes, but the propeller turns in the rear of the wing-surface, instead of before it, and the pilot and his passengers sit *below* the plane in a rather heavy-looking girder structure mounted on twin wheels. In front of this fuselage a fore elevating plane is carried, like that used on a biplane, while the tail consists of a very broad horizontal rectangular plane, with a vertical rudder above it. At a casual glance the machine really suggests a half-finished biplane more than a monoplane.

This same device of seating the pilot below the planes, as beneath a roof, was followed in the type known as the Blériot XII. The usual girder framework was used, but was larger than that of the cross-Channel type, and the big single plane spread right across the top of it at the bow. Beneath the plane, on the bottom "floor" of the girder, was the engine and the pilot's seat, the propeller being situated as in the XI, forward of the machine. Level with the pilot's feet, and on either side of him, close to the supporting pair of wheels, were two small balancing flaps, while along the upper portion of the girder frame, behind the main planes, ran a big horizontal fin, for aiding the stability of the aeroplane. The tail was formed of a horizontal frame, crossing the girder, with two more balancing flaps below it, on either side of the wood-work, and a vertical rudder fixed above the girder. Such was the first racing and passenger carrying type of Blériot monoplane, and it was certainly not as pleasing to the eye as the commoner XI type.

Before dismissing the Blériot machines I must mention one of their most novel features. This is the system of control, which is one of the neatest adopted in aeroplane work. It consists of a single movable pillar, on which is mounted a motor steering wheel. At the foot of the pillar is a metal dome, like the top of a huge bicycle bell, and to this dome are attached all the wires working the various controls—warping, elevator, etc. The mere action of keeping this lever vertical when the machine banks over performs the operation necessary for bringing it back to the horizontal position, for a right and left motion of the pillar warps the wings, and a push or pull operates the elevators on either side of the rear horizontal tail plane.

If imitation is the sincerest form of flattery, it must be confessed that the Blériot monoplane has been vastly flattered, for there are any number of monoplanes in Europe and America which, though not called Blériots, are of the "Blériot type." This is only natural, for the Blériot has done some splendid work, and has made and beaten many records for its pilots. It is one of the best of modern aeroplanes.

Another foreign monoplane which attracted great attention by its Channel work, and by its flights in a gale of wind at the first flying meeting at Blackpool, is the "Antoinette," originally piloted by Hubert Latham. It differs greatly from the Blériot in appearance and detail. In the first place the body is boat-shaped, triangular in section, with a bow like that of a skiff. It

tapers sharply towards the stern, and is enclosed all the way by fabric. The planes are set at a marked dihedral (V-shaped) angle, and taper towards their outer edges, being considerably broader at the point where they are fixed to the body than at their farther ends. They are delicately cambered, and at the rear outer edge of each a hinged balancing flap is fixed, no system of warping being included. These balancers or ailerons can be moved for balancing purposes, one being lifted, while the other is depressed.

The tail is quite different from that used on the Blériot. It has rather the appearance of a dart. A hinged, horizontal plane, of triangular shape, with the apex pointing over the stern, is used as an elevator rudder, while above and below this are two vertical, triangular rudders, for ordinary steering purposes, the apices of these being also set towards the stern. There is, in addition, a vertical, triangular fin set in front of the top rudder, along the upper edge of the framework, and viewed from the side the tail has something of the appearance of the feathers of an arrow.

The body, which is covered with smooth, polished cloth, contains the motor at the bow, with the pilot's seat immediately behind this, level with the rear edges of the planes. It is mounted on three small wheels forward, while a single skid, curling backwards, protects and supports the tail. The planes are braced by wires radiating from a single perpendicular pillar set in the bows, and a two-bladed tractor propeller revolves in front of the machine. The planes are covered

with polished cloth, laid over an aluminium framework, and have a large span, and in one of the later models a 100 h.p. "Antoinette" motor was used.

The control apparatus is more complicated than that of the Blériot machine, consisting as it does of two motor wheels, one on each side of the pilot, and a pivoted foot-bar. To the latter are attached the wires operating the vertical rudders, for ordinary horizontal steering, a push of the right or left foot turning the aeroplane in the required direction. The twisting of the left hand motor-wheel operates the balancing ailerons on the planes, and the turning of the right hand wheel, forward or backward, lifts or depresses the horizontal elevating rudder at the back of the machine.

A still later type of "Antoinette" has flexible wings, and the ailerons are done away with, the controls being operated in the same manner as before.

In recent times, as I write this, the "Antoinette" has not come so much before the public as it did in the days of its first appearance, when Latham twice attempted to con it across the Channel. It is a good and picturesque machine, however, and has made many fine flights. If further proof of its efficiency is needed it can be found in the fact that there are many machines now built which follow the lines of the "Antoinette type," so that this aeroplane, like the Blériot, has also been flattered sincerely by imitation!

A monoplane which has done some good work,

and is well known, is the Robert Esnault-Pelterie machine, commonly known as the R.E.P. In appearance it is not unlike the "Antoinette," but in the original types there was one marked difference—the planes, instead of being set at the ordinary dihedral angle, were set at a reverse dihedral, dropping downward on either side of the body.

The body of the aeroplane is boat- or cigar-shaped, not tapering towards the stern, as is the case in the "Antoinette." It is mounted on two wheels, one under the bow and one at the stern; but there are also small wheels at the outside edges of the planes, so that in starting the machine runs on the centre wheels and on one of the plane wheels, heeling over at an angle until, as the speed rises, it becomes horizontal, running on the framework wheels only before lifting into the air. The body is formed of welded tubes of steel, while the planes are built up on a wooden framework strengthened with steel. They are fitted with a warping attachment.

At the rear of the pilot's seat, and extending towards the stern, is a vertical fin, for stabilising purposes, and at the rear is carried a vertical rudder for vertical control. As in the Blériot XI and the "Antoinette" machines, the propeller is situated in the bow, in front of the planes.

The R.E.P. pilot sits just astern of the engine, and steers his machine by the operation of two levers, the pushing or pulling of that on his left operating the horizontal elevator in the stern, the movement of that on his right controlling

the ordinary vertical rudder; while, for the purpose of warping the wings, he uses the left-hand lever, but pushes it sideways. A feature of the R.E.P. machine is the absence of wires, the number of which is so notable in the case of most other aeroplanes.

At the time of writing I was courteously informed by the editor of *Flight* that the latest R.E.P. machine has its planes set at a very slight dihedral angle, so that the characteristic drooping wing aspect of the earlier types will no longer be noticeable. The body is also more like that of the "Antoinette," while the vertical fin is diminished.

A very fine monoplane of recent development and splendid success is the Nieuport machine, which in March, 1911, held the world's speed record, and also the world's distance record for passenger carrying. At Châlons, in March, this aeroplane covered 63¼ miles, with a pilot and a passenger, in exactly one hour—a very fine performance; while at the finish of the flight it had travelled 93¾ miles in 88 minutes and a few seconds.

It can be understood from this that the machine is at once speedy and efficient; and if further proof of its qualities is needed, it may be mentioned that the French Army have purchased the military type of the machine for service in West Africa.

The appearance of the Nieuport is neat, and rather different from that of the other monoplanes with which I have so far dealt. The body is of a

peculiar design. You can get a very fair idea of it by placing an ordinary long violin case on its edge on the floor. The rounded large end then represents the bluff bow of the Nieuport monoplane, and the tapering portion of the case represents the covered-in portion of the body tapering away to the tail.

Beneath the blunt bow is a pair of wheels, mounted on steel tubes, and between them is a stout steel skid running backwards towards the stern. These together form the landing and supporting chassis for the body. On either side of the bow project the wings, which are delicately cambered, and are set at an unusually small angle of incidence. They are arranged laterally at a slight dihedral angle. Well up in the front of the body is the Nieuport engine, driving a two-bladed propeller. The tail consists of one horizontal, semicircular plane, curved edge forward; at the back of this, along the straight edge, are two small semicircular horizontal rudders, hinged, for the purpose of elevators. These are set with the curved edges pointing astern, and between them is a vertical rudder. Sometimes two semicircular tail planes are fitted along the body, one in front of the other, with the elevators and rudder behind the rearmost.

The pilot sits in a bucket seat in the body, enclosed around his waist and legs, and controls his aeroplane by the movements of two foot pedals and one brass lever—brass, in order that its proximity may not affect the compass, as it might do were the lever of steel. To preserve his

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lateral stability—to right his machine should he find it tilting sideways or rolling badly—he employs the wing-warping method, operated by the pressure of one or the other of the foot-pedals, thus lessening or increasing his resistance on either side, as he wishes. For the control of his rudder, or of the elevating planes, he uses the one lever, pushing or pulling it, or moving it sideways ; while on this lever there are fixed, in addition, small attachments for controlling the motor and switching off the engine.

The Nieuport, like the R.E.P., is remarkable for the absence of wires ; and it also possesses the advantage of portability, as the wings can be dismounted with ease and rapidity. It is said to possess a very fine gliding angle, and its makers claim that it will glide to a radius equal to twenty times its height, so that a pilot at a fair altitude has plenty of choice in the matter of a landing place should his engine stop and so force him to come down at once. If he were half a mile up he would be able to pick out a spot within a radius of ten miles for an alighting place—a very useful power in a wooded or much populated country.

Another monoplane, which is of a distinctive type, is M. Santos-Dumont's " Demoiselle." This must not be confused with the same inventor's first aeroplane, that so astonished the Aviation Commission when it flew twenty-five yards. It is a machine of later development, and is notable for its small size, being a miniature monoplane, very speedy owing to its small plane spread, and more or less intended for carrying light weights.

The body consists of a triangular steel frame, mounted on two wheels and a skid aft, and stayed by wooden ribs. At the apex of the frame is carried the engine, driving a two-bladed tractor propeller, and on either side of this project the small ribbed wings, of light build and delicately cambered.

The aviator sits at the base of the triangle, below the plane, and controls his machine by means of two levers and by the movement of his own body. A lever on his right operates an elevator that is fixed in the tail, while that on his left moves the rudder. Fixed to his back is a small lever which pulls the cords controlling the warping arrangement of the planes; and this is so arranged that the natural swaying of the pilot's body as the machine heels over this or that way operates the control in the manner necessary to right the aeroplane. The Santos-Dumont tail is of distinctive design. Viewed from above the horizontal elevating plane has a rather starfish or bat-wing look about it, while the rudder for horizontal steering is shaped something like the feathers of an arrow, with the pointed apex projecting backwards over the stern. The "Demoiselle" is a speedy machine and has made good flights, but is rather dangerously small for the inexperienced aviator. A rough idea of its main lines may be got by procuring a metal triangle such as is used in bands or orchestras, placing it on its base on a table, and holding a flat sheet of paper, for the plane, across the apex!

A monoplane which you may see mentioned

pretty frequently is the Hanriot, which is a popular machine in France. It is something like the "Antoinette" in appearance. The body is boat-shaped, very finely polished, and tapers gracefully from the bow to the stern; it is mounted on wheels and skids, the wheels being so constructed that they rise above the skids on receiving the shock of a violent landing. The planes extend on either side of the bow, and the rear of each wing can be warped by means of a control wheel situated on the pilot's left. In the tail are triangular, horizontal planes and elevators, which are operated by a wheel on the pilot's right, while a vertical rudder between the elevators is moved by a pivoted foot bar. A two-bladed propeller is mounted in front of the bow. The machine is well finished, and has been found very efficient.

A monoplane of German origin is the Grade, the planes of which are very like those of a Blériot. The framework, however, is unique, consisting of a single, tubular backbone, running fore and aft, mounted on twin wheels at the bow, on either side of which the planes project, set at a dihedral angle. Between these planes a vertical fin is erected for stabilising purposes, and in the tail is a vertical rudder and a horizontal elevator. The Grade has done some good work and may be developed to a further extent.

I must now leave the foreign monoplanes, and proceed to other machines. There are, of course, many other monoplanes in existence; but as a rule these are built on the standard type lines, with only trivial differences. And those

which are unique have not yet done work that has made their names known the world over.

As is the case with the monoplanes, the number of biplanes is legion. But here again there are certain standard types which are exceedingly well known, while multitudes of the other machines are constructed on these standard lines, the Farman type being particularly popular. It is to these standard aeroplanes, or to very successful, distinct types, that we must chiefly devote attention; and, taking them in alphabetical order, the first aeroplane on the list is the French Breguet biplane, which recently carried thirteen passengers, and has been largely purchased by French military authorities for use as an Army machine.

It formerly went by the quaint and rather uncomplimentary name of "The Coffee Pot," owing to its unusual appearance.

The most original point about the Breguet is that it is practically all steel, while there is an almost complete absence of wires, which are present in such numbers in most other biplanes. Every possible part of the Breguet is of metal. The leading edge of the planes is bound with aluminium; the spars are of steel tubing, thick and strongly made. The fuselage is practically all steel.

The result of this is that the biplane is essentially a strong machine, while it is also claimed that its metallic construction makes it especially useful for wireless telegraphy work, a point of particular importance for military purposes. The fuselage of the Breguet machine looks not unlike the thin body of a dragon-fly, and is

covered in with metal from front to rear, where it tapers to the tail, which is of cruciform design, and is very large. It consists of one horizontal and one vertical surface, jointed to the peak end of the fuselage, and serving as a rudder and an elevator combined.

At the fore end of this dragon-fly, or boat-shaped, frame is the engine, mounted on a strong bed of steel tubing, and driving a two-bladed tractor propeller, in front of the main planes, there being no forward plane of any description on the Breguet machine. The pilot sits behind the engine, in a closed-in bucket seat, which is in rear of the two planes. These planes are, of course, fixed one above the other, and tilted at a fairly big angle, which, however, can be altered at will, one plane being below the bow of the fuselage and the other well above it. They are supported by four steel tubes, or spars, and are particularly interesting in that they are hinged by a patent device, and can be folded back on each side of the machine, flat, like the wing cases of a beetle. The aeroplane can thus be packed up in quite a small space, and its resulting portability makes it valuable for army work; it can be dismantled in five minutes, and opened out, ready for flying, in eight, no time having to be wasted in "tuning up" wires. The planes are double surfaced, and their ribs are attached in a patent manner to the supporting spars, in such a way that the plane surface is made very supple, or elastic and this quality gives the aeroplane a high degree of automatic stability and makes it a very safe flyer.

Beneath the lower plane is the landing chassis, consisting of three small, heavily tyred wheels, reinforced by four very stout skids. Patent shock absorbers are also fitted to render landing still easier.

The pilot of the Breguet controls his aeroplane when flying by means of a wheel mounted upon a pivoted pillar. By pulling or pushing this pillar to and fro he controls the movement of the elevator in the tail ; by swaying it to left or right he is able to warp the rear edge of the upper planes to preserve his stability, and by turning the wheel in the usual manner he operates the horizontal rudder for steering. Compared with some controls, this system is very simple and efficient. The military model of the Breguet has a supporting surface of 365 square feet with a span of 45 feet 9 inches, the lower plane, however, being of smaller span than the upper surface. This cruiser type, as it is called, can seat the pilot, and two passengers, and weighs 1,200 lb. without passengers or fuel. It can carry 660 lb. and with a 60 h.p. Renault motor, driving the propeller at 800 revolutions per minute, develops a speed of 53 miles per hour. There are various other models, however, including a racer carrying four, driven by a 130 h.p. Gnome engine, and developing a speed of 82 miles an hour. Such a machine as this would certainly be a formidable rival to a Zeppelin airship, and the Breguet is already making its mark in military work on the Continent. It is a thoroughly interesting and practical machine, and has a taking appearance

of strength when viewed at close quarters; while in the air, by a stretch of imagination, it might be likened to a beetle. Its efficiency is amply proved by its passenger-lifting feat referred to earlier in this account.

In alphabetical order, the next machine we have to note is the American Curtiss biplane.

This machine, built and designed by Mr. H. Glenn Curtiss, is very neat and compact in appearance, and in its general lines is not unlike the famous Wright biplane. In the first place there are, of course, the two superimposed plane surfaces, braced by wires and supported by spars in the usual manner. The machine is mounted upon a strong chassis, supported by three wheels, two directly beneath the machine and one forward on a kind of outrigger. Still farther in front, carried at the apex of a triangular spar frame is an elevator of biplane type, like a model replica of the planes behind it, and at the stern, at about the same distance from the back of the machine as the elevator is from the front, is a cruciform tail, consisting of a horizontal plane surface and a vertical rudder.

The ailerons or balancers, for preserving the stability of the machine, consist of two pivoted planes, carried between the main planes, at either end of the machine, and so mounted that one half of each balancer is directly between the upper and lower planes, and one half projects beyond them to the front of the machine.

The pilot and engine are carried on the centre of the lower plane, the engine being behind the

pilot's seat, driving a two-bladed propeller in rear of the main planes. For control a steering wheel is provided, the pushing or pulling of which operates the biplane elevator, depressing it or raising it as may be required.

The cables controlling the movement of the balancers are attached to the pilot's seat, and are operated by the natural swaying of the body in the attempt to balance the aeroplane should it heel over when turning or in a gust of wind.

The racing Curtiss is a smaller copy of the larger machine. In one typical machine the span of the planes is $29\frac{3}{4}$ feet, with an area of 272 square feet. It is a speedy and efficient flyer, and there are a good many of the type in existence in America.

An exceedingly important variation of the Curtiss biplane has also been produced for naval work. This machine is mounted on floats, and has proved itself able to rise by its own power from the surface of the sea, much as a gull rises from the wave tops. When still further improved this biplane may be of vast importance in naval war.

We must now return to France once more, and next in order comes the famous Farman aeroplane—or, rather, aeroplanes—for there are two types of Farman machine, the Henry Farman and the Maurice Farman. We will deal with the Henry Farman first.

Undoubtedly the Farman is one of the best-known biplanes. It has done splendid work, both in competitions and in ordinary private flying, and

in the hands of the many capable pilots who pin their faith to it has proved a very safe aeroplane—by no means an unimportant consideration. Probably most of my readers remember the great London to Manchester race, in which Paulhan and Grahame-White covered themselves with glory, at a time when the public scarcely believed that aeroplanes were capable of flying more than a very few miles at the most. Both airmen were then using the Farman biplane, and the successful completion of the flight without accident, and in a surprisingly small time, was a splendid proof of the efficiency of this particular type of aeroplane.

The general shape of the Farman aeroplane, viewed from the side, is that of a diamond as depicted on a playing card. At the forward point of the diamond there is a monoplane elevator, carried at the peak of a spar framework. At the rear point is a biplane tail, with rudders, and at the upper and lower centre points are the two planes, forming the supporting surface of the machine.

The fuselage is supported upon two pairs of small wheels, mounted over two stout skids, and protected from breakage by rubber shock absorbers, which tone down any violent jars which may be occasioned when the machine is coming to land. Above the wheels is the lower plane, at the centre of which, close to the entering edge, sits the pilot, in advance of his engine. Above him is the main plane, in many of the later types, and in racing models, of considerably greater span than that of the lower plane. The usual polished spars support the plane surfaces, and many gleam-

ing wires brace them in various directions. At the back of the upper main plane and of the lower plane are two pairs of ailerons, hinged, and acting as flaps for the purpose of balancing the machine and increasing the resistance on either side as may be required. Forward, level with the pilot's face, is the monoplane elevator; astern is the tail, of biplane pattern, with twin rudders, pivoting just at the back of the tail planes. In addition the original type of Farman used to have side panels at the tail, giving it the appearance of a box-kite, towed along behind the main planes; but in standard models these panels are now done away with. Engines of varying patterns are used, driving a two-bladed propeller, in rear of the main planes, behind the pilot.

The control is simple, consisting of one lever, operating both elevator and ailerons, and a pivoted foot bar, to the ends of which are attached the cables which move the rudders.

The Farman aeroplane is a graceful machine in flight, and makes a stirring picture as it drives steadily along, to the roaring note of the motor engine, heeling over, perhaps, and then quickly righting itself, as the flaps of the balancers dip down in response to the pilot's controlling movement. Under the control of men like Grahame-White or Farman himself the machine can do wonders.

In size the machine, of course, varies considerably; but the average span of the upper plane is, say, about 30 feet. The lower plane has very often only about half the span of the

upper surface, the total area of support being lessened in this case in order to make the machine more speedy. This alteration adds largely to the picturesqueness of the machine in flight.

The Maurice Farman is similar in many respects to the aeroplane just described, but it is impossible for a man who understands aeroplane lore to confuse the two, for the framework is quite different in both machines. The Maurice Farman employs what is known as the Voisin fuselage, which will be described in further detail when we come to the Voisin aeroplane. Suffice it to say that, viewed from the side, the Maurice Farman does not present that diamond shape that is displayed by the Henry Farman.

The skids, in the first place, instead of being short, turn right up in the front of the machine, and join the outrigger spars which support the monoplane elevator, carried in front of the main planes. These skids are very strongly braced, and form a splendid protection to the more or less fragile planes behind, in case of a rough landing or a collision with an obstacle.

As in the Henry Farman, the skids are also reinforced by stout wheels. In the latest type of machine, the main planes are covered with a double surface of fabric, and their corners are rounded at the front, both in the main plane surface and the biplane tail surfaces. They are supported, as usual, by rows of spars, and by bracing wires, and are fitted with two pairs of hinged balancers, as in the Henry Farman. The tail biplane, however, instead of being carried

at the peak of a triangular framework, is supported at the rear of a kind of girder which has no tapering shape. Twin rudders turn at the rear of the biplane, which is raised from the ground on a small skid.

In a recent model, the engine and the pilot's seat, on the lower main plane, were enclosed in a smooth boat-shaped covering of fabric, and a small wind shield was erected in the bow just before the pilot. The latter, in flying the Maurice Farman, uses a different system of control to that employed on the Henry Farman.

Before him, as he sits in his bucket seat, is a motor steering wheel, mounted *horizontally*, instead of vertically, as is the usual practice. When, on leaving the ground, he wishes to raise his elevator, he pulls the wheel toward him; he wishes to perform a *vol plané*, and he depresses the elevator by pushing the wheel forward away from him. He tries a turning movement, and spins the wheel round, bringing the rudders into action; and at the same moment as his machine banks over he presses down one of two foot pedals which operate the aileron flaps and thus steadies his aeroplane.

The Maurice Farman, like the Henry Farman, is a very good all-round machine, and has done excellent work in France.

Another standard type French aeroplane is the Sommer biplane, which in general appearance is not unlike the Maurice Farman. It is distinguished by its large, up-curling skids, which are rather different in appearance from those on the Farman, though they also turn up in the front of

the machine to meet the elevator spars. The framework which supports the tail, however, tapers slightly, and the tail itself is quite different from that used on the Farman aeroplanes. It is formed of one horizontal elevator plane, with small vertical rudders above and below the centre of it.

The stabilising flaps, hinged to the rear surface of the upper plane, are very large, and more or less of half-lozenge shape. Two half hoops support the tail, and beneath the planes are two wheels. From these the two curling skids, not very heavily built, sweep in a bold curve forward, to the monoplane elevator, which is carried at a level with the pilot's face. The body of the machine is built of tubular steel, and is therefore able to stand rough landing. One double-bladed propeller is carried in rear of the main planes, and the machine is controlled by single lever and pivoted foot bar for the rudders. The machine varies in size, but a typical model has a span of 34 feet, with a total supporting surface of 568 square feet.

The next biplane that we must mention is the famous Voisin, which has undergone many changes since the first aeroplane of that name left the ground. It was one of the very first successful aeroplanes, and was made famous by Mr. Henry Farman, the Baron de Caters and others in its early days. The early type of machine had the appearance of a giant box-kite, and was by no means graceful or light looking.

Its main supporting surface was formed by the usual upper and lower planes, which were joined

by four panels, dividing the machine into cells. A biplane tail was carried at the rear of a non-tapering girder framework behind the machine; and this tail was also fitted with panels, the rudder turning inside the box-kite so formed. This biplane tail was very large, and rather clumsy in appearance.

Forward of the main planes there was a monoplane elevator, but the peculiarity of the machine was that, contrary to the usual practice, no ailerons and no warping control for balancing were fixed. The necessary stability was secured by the action of the fixed side panels on the air, The control was by means of a steering wheel, the action of pulling and pushing it depressing or raising the elevator, while turning it in the ordinary way brought the rudders into action. A motor driving a two-bladed propeller behind the main planes was mounted in the centre of the lower plane just in rear of the pilot's seat.

Such was the first Voisin type aeroplane, and a very successful machine it was on the whole. It was possessed of a very good gliding angle, a by no means unimportant quality, but it was not particularly fast, nor very graceful. However, the Voisin has undergone any number of changes, and some of the later types are extraordinarily different from the first machines of the name.

In 1910 the Voisin appeared without its most distinctive features—the side panels; but the tail was still practically unaltered. The next change was noticeable in Voisins of the racing

type. They now present very much the same general appearance as the Farman, save in the matter of tail and fuselage.

There are no longer panels of any description, while both upper and lower planes are of lighter-looking build, the upper planes carrying balancers at the rear edge, as in the Farman. The tail is of cruciform design, like that used in the Sommer machine already described—a vertical rudder and a horizontal plane. The monoplane elevator is still preserved. The airman uses pedals to control his ailerons, and the wheel for the elevator and rudder, as in the early models.

One of the main features of the Voisin is the torpedo-shaped, girder fuselage, coming to a peak in front of the airman, where the elevator is mounted. A fairly recent type of Voisin is the freak machine, called the "Canard," which is something like the early Voisin, save for the fact that it puts the cart before the horse, so to speak, and flies with its tail in the front. It is a strange-looking machine altogether, and not very prepossessing. At the time of writing this machine is being fitted with floats, so that it may be adapted for use on water.

Next on the list comes a name which has already appeared frequently in these pages. This is the name of Wright, and it is with a reference to the Wright biplane that I must close this short account of some of the foreign aeroplanes. This machine, like many others, has undergone and is undergoing alterations from time to time. Presumably slight changes and improvements will

continue to be made, and I think, therefore, that the best Wright machine to describe is the well-known and most popular standard type that was originally employed to break and make sundry records.

Put briefly, this is a biplane with twin vertical rudders at the rear and a biplane elevator in front, driven by two propellers behind the pilot's seat on the lower plane. The framework of the machine was built up of spruce and ash, mounted on two long skids. The control was operated by two levers, that on the right operating the rudder and the warping arrangement for the planes, while that on the left of the pilot was used for controlling the elevator. A typical example of the machine weighed some 1,050 lb., with the aviator, and had a breadth of 41 feet, by no means a small size. The machine was started by being set to run along a single rail, on a trolley, the necessary impetus being given by the falling of a heavy weight from the top of a wooden pillar, which tugged a cable fastened to the front of the trolley. By the time the machine had reached the end of the rail it had received sufficient impetus to rise into the air. This method was efficient enough, but necessitated the employment of a large amount of material for the starting of the aeroplane, so that if the machine came down at any deserted part of the country it could not be got into the air again. The French and English pattern Wrights, therefore, were fitted with wheels in addition to skids, and in 1910 the American Wrights adopted the same improvement. The

French Wrights, too, carry an elevator in the tail, consisting of a small horizontal plane immediately in rear of the twin vertical rudders behind the machine.

In the later Wrights, however, a characteristic feature of the machine has been done away with, the forward elevator having been abolished, the horizontal plane fitted in the tail now serving as elevator, and the vertical rudders being unchanged. In the Baby Wright machine, built for racing, which won the second place in the 1910 Gordon Bennett contest, there are two vertical rudders, with a horizontal elevating plane behind them, as in the Continental Wrights, while two vertical triangular planes, or blinkers, are fitted to the fore part of the skids by way of steadying the machine, which is mounted on skids and wheels. This is an example of the later Wright machines, and a very pretty example it is, of tiny dimensions. Its span is only 21 feet, and the great two-bladed propellers look quite out of proportion to the small planes in front of them. But it has proved its efficiency well enough. The later English-built Wrights are of much the same design, "blinkers" being used instead of a forward elevator, while a horizontal elevator plane is carried behind the rudders. Good wine needs no bush, and the efficiency of the Wright machine is too well known to need any eulogy here. It is the most popular machine across the Atlantic.

With this I must leave the foreign aeroplanes and turn to the British machines. There are many other machines of odd types, or built on

standard lines, but with these it is unnecessary to deal.

I have made no mention of the motor engines which drive the aeroplane. It is true that without the motor the aeroplane might never have flown as it is flying to-day—not at this date, at all events. But the differences between the various engines are nearly always purely technical, so that my readers would need engineering training to understand them. The Gnome rotary engine is one of the most popular types, in which the whole engine spins round, the cylinders being set radially like the spokes of a wheel. But there are many other engines, among them being many excellent British types. My readers who have a bent for engineering must read of these elsewhere, for when all is said and done, the making of the motor is the engineer's work, and not the aeroplane builder's. There is the same difference as in the building of a steam yacht's delicate hull and the making of her turbines.

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CHAPTER XIII

British Aeroplanes

THE array of foreign aeroplanes is indeed a formidable one. Biplanes, monoplanes and "assorted types," they are numbered by scores, and so often do the well-known names of Farman and Blériot, and others of their fellow-countrymen, appear in the aviation news, that there is too great a tendency on the part of Britons to decry their own country's machines. In fact, not so very long ago I asked a friend who takes an average interest in aviation, getting his facts from newspaper reports, to give me a list of British machines. He could give me the names of only two aeroplanes, both biplanes!

It goes without saying that there are more than two British machines in existence. There are a large number of biplanes and a good many monoplanes, sound aeroplanes, too. As regards workmanship there is no doubt that some British firms can turn out machines which equal or surpass in the excellence of their construction anything that can be made on the Continent. This holds good of all branches of aeroplane work—fabric making, engines and woodwork. In all these details many of the British planes are the equal of the best examples of Continental workmanship.

The one thing we do lack is enthusiasm. If

aviation were supported more keenly, we could rule the air. As it is, we are behindhand.

First of all, therefore, I will deal with some of the British monoplanes, taking a selection of the best machines for description, as it is obviously impossible and useless to describe every machine now built.

One of the most distinctive and original British monoplanes is "The Valkyrie," built by the Aeronautical Syndicate, Ltd. This machine is the outcome of a series of experiments, originally conducted on Salisbury Plain, where for over a year the syndicate did a great deal of hard work. Eventually "The Valkyrie" was evolved, and the syndicate brought it to the big flying ground at Hendon, not far from the Welsh Harp. Here flights were made at once, a flying school was established for "The Valkyrie" machine, and an aeroplane construction works was quickly in full swing. It was this head-quarters, as my readers may recall, that I described in the chapter on the building of the aeroplane.

"The Valkyrie" is undoubtedly a novel machine—a type entirely of its own. It is a monoplane, but the engine, propeller and main planes are *behind* the pilot, instead of in front of him, as in the Blériot and all other monoplanes. The advantages given by this system of arrangement are two: the pilot has a clear view of the country, underneath and immediately before him, and there is no oily propeller blast in his face as he flies.

The two main planes, then, are set at the rear

end of the framework. This latter is of very safe design, consisting of two huge skids, over 20 feet long, set about 9 feet apart, curling from the stern right up to the front of the machine, well beyond the pilot's seat. These widely set skids prevent the machine overturning when running, and make landing very safe, even on rough ground which may be met with in the course of a trip across country. "The framework," say the makers, "is in the nature of an immense spring, and is designed to give or bend to the shock of a rough descent."

The main planes can be dismounted, too, and the machine made ready for transport in a short space of time.

Behind the main surfaces, at the rear of the skids, is a big double rudder, controlled by wires from a pivoted foot-bar on the pilot's seat. At the rear outer edge of either wing are hinged balancers, though the wings can be fitted with warping control if desired. At the front end of the skids beyond the pilot's seat is a small fixed plane and also a monoplane elevator. The engine and propeller are just behind the pilot's seat, between the skids, the propeller revolving in the centre of the machine, well in front of the main planes; while there is quite a considerable space between the pilot's seat and the front of the machine where the elevator is mounted.

The resulting appearance is perhaps a trifle "spidery," but decidedly not ungraceful. With its engine and metal work polished, wires gleaming, and delicately cambered planes, set at a slight

dihedral angle, the racing "Valkyrie" is one of the most picturesque of British aeroplanes.

The controls are operated by the pivoted rudder bar and by a single lever. The angle of incidence of the planes—the angle at which they meet the air—can be altered as desired, to give slow or fast speed. The chassis is supported by two pairs of stout wheels fitted with shock absorbers or rubber. "The Valkyrie" has been found to be a very safe and efficient craft, flying every day at Hendon with passengers and learners, and is altogether a good British machine, distinct from any monoplane of foreign build.

Another very pretty and carefully built British monoplane, which has proved its worth by flying well, is the Martin-Handasyde aeroplane. A really beautiful specimen of this machine was shown at the last aerial exhibition at Olympia, appropriately called "The Dragon Fly"—for its appearance in flight is certainly suggestive of one of those great greenish insects which hover over stagnant pools in English woodland.

In general shape it is not unlike the "Antoinette," which I have described among the foreign machines. The fuselage is of wood, boat-shaped, and tapering sharply from bow to stern. In order to diminish the effect of skin-friction in flying, it is very highly polished. At the bow is mounted the engine, and the two-bladed tractor propeller. In the rear of the engine, on either side of the machine, spread the planes, which are double surfaced, and cambered in the usual manner, tapering slightly, so that their

width at the outside ends is rather less than at the point where they are attached to the fuselage.

At the stern of the body is a tail, supported by a skid from contact with the ground, and formed of a big horizontal elevator with a vertical rudder passing through it. The bow of the aeroplane is supported by two stout wheels, and a big up-curling skid, extending forward, beneath the propeller. Seated in rear of the engine, the pilot finds, in front of him, a motor steering wheel, mounted upon a perpendicular pillar. By twisting this to left or right he is able to warp his wings, for preserving the stability of the aeroplane while the action of pushing or pulling it operates the cables which raise or depress the elevator. The rudder is controlled by the foot-bar, pivoted in the centre, with the cables attached to either end. The whole machine is splendidly finished and compares well with any Continental monoplane. It has flown well at Brooklands.

The "Blackburn" is another British monoplane which has a remote resemblance to the "Antoinette." Here again the fuselage is triangular, and boat-shaped, tapering back from bow to stern, It is built of ash, in the form of a girder, and in front is covered with polished wood, the stern section being covered with fabric. The main planes are spread out on either side of the bow, are strongly built, and carry a small skid at each outside end, for protection. The tail consists of a horizontal surface, with vertical rudders, triangular in shape, much the same in appearance as those used on the "Antoinette,"

and there is a triangular fin for stabilising purposes mounted on the upper rear part of the fuselage.

The tail is supported by a skid, and beneath the bow of the aeroplane is a strong chassis, consisting of two pairs of small wheels and two skids. The two-bladed propeller turns, as usual, in the bow of the machine. The controlling system is patented. The sideways movement of a pillar bearing a wheel operates the rudder; the turning of the wheel warps the wings, and the movement of the wheel up or down controls the elevator. A patent automatic stability control is also fitted to some of the machines, consisting of a pair of ailerons controlled by a compressed air piston, which works automatically, according to the position of the aeroplane in flight.

The Weiss monoplane is an interesting machine, as it is a real attempt at a bird-shaped aeroplane. Mr. José Weiss, my readers will remember, has long been interested in the construction and behaviour of gliding machines, pure and simple. He has carried out some hundreds of experiments with various models of different sizes, and the Weiss monoplane shows the practical result of these experiments. It is essentially bird-shaped, departing altogether from the usual form of aeroplane, adopted by M. Blériot, and hosts of other inventors.

In appearance it is like a great gull. Its body is short and built to bird-shape, being mounted on three wheels, carrying as usual the pilot's seat

and the motor, an Anzani engine. The form of plane adopted is the most striking feature of the machine, the wings being fashioned like those of a gull, humped aggressively near the body, carried well back in a bold sweep, and curling up at the outer ends. Automatic stability is aided by the curve at the wing tips.

At the time of writing the machine, which is at Brooklands, is in a more or less experimental stage, and has been tested with and without a tail. It has flown safely, but in all probability is handicapped by the low h.p. of the motor with which it is provided. This is a pity, for undoubtedly Mr. Weiss' excellent work in connection with gliders gives every promise of a notable success with his full-size machine. Indeed there have not been wanting those who affirm that the form of plane adopted is the correct shape and will make its appearance prominently in future machines. At any rate there is no doubt that Mr. Weiss deserves every success with his novel aeroplane.

The name of Howard Wright is mostly known in connection with biplanes; but there is also a Howard Wright monoplane, of a distinctive type, although the name is also associated with British-built monoplanes of the Demoiselle and Blériot types.

In appearance the Howard Wright monoplane is something like one of the early Blériot monoplanes. The framework is of a girder type built of wood, and mounted upon three wheels, two supporting the forepart and one the tail. Rect-

angular planes project on either side of the motor and pilot's seat in the bow, supported by wires carried at the apex of two triangular frames, as in the first Blériots. A tractor Howard Wright propeller is mounted forward. At the tail is a triangular rudder, before which are two elevator planes, controlled by lever from the pilot's seat. The machine has made successful flights, but is not so well known as the Howard Wright biplane.

A machine of very novel shape is the Dunne monoplane, which is tailless, the aeroplane being in the shape of a V, the point forming the bow, and the planes sweeping back on either side of this at a wide angle. It is very like the Dunne biplane in general design, however ; and as I shall treat of this machine later I will not describe the monoplane ; suffice it to say that it is built on original and scientific lines, the actual form of the planes giving the effect of automatic stability, no matter at what angle stray gusts of wind may strike the machine.

A pretty monoplane of British manufacture is the Handley-Page, the planes of which incline to the form of a bird's outspread wings. The body, of polished woodwork, mounted on a stout skid and a pair of wheels, is fish-shaped, tapering very finely aft, where a horizontal elevator and a vertical rudder are hinged, controlled by the pushing or pulling of the vertical steering column before the pilot's seat. The planes, which are very delicately made, are humped at the fore part, sweep back in a rapidly falling curve, and turn up gracefully at the rear edges, and are warped by

the swaying of the steering pillar to left or right, while the rudder is operated by the turning of the steering wheel in the usual manner. As is usual, propeller and engine are carried at the bow, and the machine flies well with a comparatively low powered engine.

It must be confessed that the general run of British monoplanes, save for a number of more or less unknown experimental machines, are built to foreign standard types, and should scarcely be included under the heading of British machines. Nevertheless some of these aeroplanes display very fine workmanship, and should at least be mentioned here. There is, for instance, the Avis monoplane built by Howard Wright. In appearance this is very much like a Blériot, and indeed is mostly built on Blériot lines. It employs, however, the peculiar Santos-Dumont tail, and this difference would immediately be noted by anyone with a knowledge of flying machines. The framework is of girder pattern, at the fore part of which are carried the two planes with rounded corners. In advance of these is a Howard Wright tractor propeller, driven by a 25 h.p. Anzani motor. The planes can be warped, and there is the usual tail elevator and triangular rudder, while two skids, mounted on two pairs of wheels, support the fore part of the fuselage. The planes are set at a slight dihedral angle. Then, too, we have the Humber monoplane, with the Blériot-type single pillar control, warping wings and Blériot XI tail—practically a British-built Blériot; and there are a number of other Blériot types constructed.

The Neale monoplane has something of the appearance of a Blériot machine, but differs in several important respects from the French type. The body is a triangular girder framework of wood, and is mounted on three wheels, one pair forward beneath the planes and one at the tail. The body is covered in for its whole length with fabric, and the tail is of a biplane type—two planes, one above the other, with a vertical rudder between them projecting outwards to the rear. The planes, set at a small dihedral angle, are fitted with balancers at the tips and flaps for aiding stability, no warping control being mounted. The motor drives a wooden tractor propeller at the bow, as usual. The points where the machine so greatly differs from the Blériot are, of course, in the tail and the shape of the fuselage.

A monoplane carrying two propellers, revolving in opposite directions, is the Spencer-Stirling, built by the well-known Spencer brothers. The machine is remotely like a Blériot, but the propellers are placed on either side of the main plane surface, and are chain driven. The wings are warped by a foot pedal, while elevators are placed on either side of the tail.

With this I must leave the British monoplanes. There are, of course, numbers of machines that I have not space to mention. Some of these are building, some have been relegated to that rest-haven for failures—the scrap heap! Some are too similar to well-known Continental types to need separate description here. On the whole, it must be confessed that there are comparatively

few British monoplanes of startling originality, but those monoplanes in existence are good machines, and need not fear comparison with any foreign machines. The Valkyrie, the Weiss, the Dunne, and the Handley-Page—these are certainly distinctive, and may do great things in the future. All honour to the airmen and inventors who are working in the midst of rather chilling indifference to establish the excellence of British machines and to build formidable rivals to the Blériot.

We must now consider the British biplanes, of which there is a goodly and efficient array.

The first of these which requires consideration is the Bristol machine. This aeroplane has attracted a good deal of attention, and has been chosen by the War Office authorities for military work, while the Russian Government have also purchased some of the machines. The Bristol is a British-built Farman-type aeroplane—and a beautifully built and finished machine it is when ready for action. There is scarcely any necessity to describe it in detail, seeing that the description of the French Farman to all intents and purposes applies also to the Bristol. But on the British military type three rudders are used between the biplane tail that is common to the Farman. The upper plane is also wider in span than the lower surface, and the engine and pilot's seat are enclosed by a torpedo-fronted wind shield of fabric, for lessening head resistance when in the air. In the big military machines seats for two passengers, besides the pilot, are provided. The control of the Bristol is operated by a

horizontal wheel on a vertical pillar. The pulling and pushing of the wheel operates the elevator—a monoplane elevator in the front of the machine—the twisting of the wheel to right or left brings the hinged ailerons on the rear edges of the upper and lower planes into action, and the movement of a pivoted foot-bar swings the rudders in the required direction. The machine is mounted upon a chassis of two skids and two pairs of wheels, and with its big, snowy planes and its glistening wires it makes a very fine appearance. With a Gnome engine and the usual two-bladed propeller behind the planes it has done excellent work.

There is also a Bristol racing biplane of very novel design. In this machine the body is something like that used on the Blériot monoplane, enclosed from bow to stern by fabric. The upper plane has a greater span than the lower, and can be warped for aiding stability, there being no ailerons on this type. The tail consists of one horizontal plane, to the rear edge of which are attached two small, hinged elevating planes, and a vertical rudder above this plane. Two stout skids and two wheels support the fore part of the machine, and the tail is kept above the ground by another skid. In this machine there is no forward elevator; and a tractor screw, in front of the pilot's seat and the fore edge of the planes, is driven by a Gnome engine. There are very few wires and spars, and the aeroplane looks fast and businesslike.

A British biplane that has done splendid

things, and won the British Empire Michelin Cup in 1910 by a flight of over 185 miles, is the Cody biplane. This machine is of heroic size, and compares with, say, a racing type of "Valkyrie" monoplane about as well as an elephant compares with a fox terrier! When you approach the aeroplane and see it at close quarters the feeling that prevails over all others is one of sheer amazement that such a massive structure should ever be able to leave the ground and to fly well.

Take the framework of the machine, supporting the engine and the elevators. Here are massive wooden beams and poles, bolted and bound together, braced and wired, and giving an unequalled impression of sheer strength and weight. Indeed, if the aeroplane is fitted with a high power engine—100 h.p.—it weighs as much as 1,500 lb. without fuel or pilot. It then has a total supporting surface of over 800 square feet. The main upper and lower planes are of great size, and forward of the machine, carried on strong outrigger spars, is an elevator of double monoplane form, consisting of two planes, of very large area, arranged side by side, one in front of each half of the biplane behind.

The machine is not unlike the American Curtiss to look at, for midway between each outer end of the upper and lower planes is a separate aileron plane, this also being of very great size. At the rear, supported by stout spars, is a big vertical rudder and a fixed horizontal plane. The machine is supported on a "Sandowesque" chassis of skids, mounted on three wheels, while

at the outer front corner of the bottom plane, on each side, is another small wheel.

The pilot sits more or less on the chassis, just forward of the edge of the lower plane, and his passenger sits above and directly behind him. The aeroplane is driven by a big two-bladed propeller, in rear of the main surfaces, while the machine is controlled by the movement of a vertical pillar, bearing the steering wheel, the rocking of this from side to side operating the ailerons between the planes, and the turning of the wheel swinging the rudder in the usual way.

Above the pilot's head is a square water tank, and a radiator is mounted in the outrigger spars between him and the forward elevating planes.

The machine is remarkably stable, and as an instance of its efficiency it may be mentioned that during the flight for the Michelin cup, already mentioned, the total weight carried, with an engine of only 54 h.p., was no less than 2,168 lb. With high powered engines the speed of the machine is from 40 to 60 miles an hour.

The De Havilland biplane, which has for some time occupied the attention of British military authorities, is a machine of rather peculiar design. The main framework upon which the engine and pilot's seat is mounted is of girder construction, torpedo shape, and built of wood. At about the centre of the girder is the engine and pilot's seat, above and below which are the usual planes. To the rear edge of the upper plane are fitted ailerons of half-lozenge shape. In front of the machine is a monoplane elevator, while the framework is

mounted on four wheels, one right forward under the nose of the torpedo girder, two below the centre, with supporting skids, and one at the stern below the tail. This latter is built up of a vertical rudder, and a horizontal plane below it. Two screw propellers are used to drive the aeroplane, and it is controlled by two levers to right and left of the pilot, operating elevators, and ailerons. The machine has made very good flights on Salisbury Plain.

An interesting and novel machine is the Dunne automatic stability biplane. A little halo of romance surrounds the building of this machine, for in the early stages the work was kept very secret. The inventor himself, in company with some Army officers, was encamped in a wild, heather-grown valley in Scotland, near Dunkeld, far from houses and towns. Here, amid surroundings of purple glens, bubbling streams, and mist-enveloped moors, grew the sheds and workshops in which the Dunne aeroplane was put together. The experimental area was strictly guarded. Canny Scotch gillies acted as sentries and allowed no one—pressmen or tourists—to approach the "magic circle" in the centre of which work was so busily proceeding.

The machine that developed within these sentry lines was of very original appearance. It was a V-shaped, tailless biplane, the point of the V forming the bow of the machine, from which the planes swept back in a wide angle; the explanation of the advantages said to be given by this form is too technical to be included here.

Suffice it to say that the design was worked out with the idea of giving automatic stability, and has justified its inventor's claims in a remarkable fashion.

The two planes, suggesting in shape an arrow-head, have their tips hinged at the trailing edges at the rear part of the machine. The pilot is seated at the point of the V angle, his place being shielded by a pointed wind screen, to lessen resistance in travelling. Behind his seat in the angle of the V are two two-bladed propellers. The control of the hinged wing-tip ailerons is operated by two levers, and the automatic balancing qualities of the aeroplane are shown by the fact that these levers can be locked into position, leaving the pilot free to take his hands off them, and let the aeroplane look after itself.

Horizontal steering is given by operating one of the wing flaps separately, this causing the aeroplane to swing round in the required curve. The machine has a natural gliding angle—that is to say, if the engine is cut off, it dips automatically and glides gently to earth; the chassis consists of skids and wheels, and the biplane is one of the most novel of British machines. When it is quite perfected it will be exceedingly valuable for military work, as a single pilot will be able to take copious notes without having to worry overmuch about his machine, the shape of which gives him stability even when it is struck by side gusts. Taking it all together, the Dunne is a very interesting biplane, notably different from any other type, British or foreign.

There is also a Dunne monoplane, built on the same lines, to which brief reference has already been made.

The Grahame-White biplane is of Farman type, but this chapter would be incomplete without a reference to the attractive Grahame-White Baby machine, which has flown so well since its first appearance at Hendon.

This little aeroplane is really a tiny Farman type machine, and is very neat and well built. The span of its planes is 27 feet, and it is built on the usual Farman pattern framework, with a particularly strong chassis of skids and wheels, adapted for landing on rough surfaces. Fitted with a 50 h.p. motor, its weight is 650 lb. and it has a supporting surface of 300 square feet.

The usual mono-elevator is mounted on the outrigger spars in front of the machine, and the tail is of the Farman biplane pattern, with two vertical rudders between the planes. Hinged ailerons, however, are only fitted to the top plane, instead of to both upper and lower surfaces. The control cables are attached to two levers, so arranged that one or both can be used, according to the pilot's desire, and the rudder is operated by a pivoted foot bar.

A very neat stream-line wind screen is built round the pilot's seat, reducing the resistance, and steel is used in the construction of the machine instead of aluminium, giving it great strength. A special four-bladed propeller is mounted in rear of the supporting surfaces, and in spite of its small size the machine can easily carry a

passenger. Its speed is between 50 and 60 miles an hour, and it has made many splendid flights, proving its efficiency beyond all shadow of doubt. It is a graceful and pretty machine in mid-air.

A biplane which has flown well in India, carrying the first aerial letter post, is the Humber. The machine, which was exhibited at the last Olympia show, was mounted on a framework very strongly suggesting that used in the French Sommer machine. In front of the planes the lightly built skids turned right up to help in the support of the mono-elevator, carried in front of the pilot. The tail consists of a horizontal surface and a vertical rudder. The upper main plane is fitted with ailerons, and has a greater span than the lower surface; while a novel feature is the presence of side panels at either end of the machine between the two planes. These panels can be twisted or turned askew by the pilot, aiding the lateral stability of the machine. It is fitted with a two-bladed propeller, driven by a Humber engine.

The Howard Wright British biplane, on which Mr. T. Sopwith won the de Forest prize by an excellent flight to the Continent, is another interesting and efficient machine. On an aeroplane of this type Mr. Sopwith flew to Windsor early in 1911, in order that His Majesty might see something of modern flight in his own park.

The aeroplane has upper and lower planes of the ordinary type, with big hinged ailerons in the rear edge of the upper plane. The tail is formed of one very big horizontal plane, with a hinged elevator behind it, and two vertical

rudders, one above the plane and one below it, while a monoplane elevator is carried forward. The control is operated by one lever for ailerons and elevators, and a pivoted foot bar for the rudders.

The framework of the machine is not unlike that of a Farman save at the tail. It is built of stout spars, braced in the usual way by wires. The engine—of varying makes—drives a two-bladed propeller in rear of the pilot's seat on the lower plane, and its weight is supported on a chassis consisting of two strongly built skids and two pairs of stout wheels, fitted with shock absorbers.

The Howard Wright is a very efficient aeroplane and has an imposing and workmanlike appearance. Its worth has been amply proved by its various performances.

Original plane design is shown in the Sanders aeroplane. The Sanders machine is a biplane, and both upper and lower planes are curved to a slight dihedral angle. The ends of the upper plane, however, having reached their maximum height, curve over and downwards again, drooping, so to speak, above the lower plane, the idea being that air thrown off by the dihedral angle of the planes below is caught in this curve at either end of the machine.

A big biplane elevator is fixed forward with twin vertical panels between upper and lower planes. This is mounted low, at the curled-up peak of a pair of girder-built skids, which are mounted on three wheels, to form the chassis upon which the aeroplane and engine rest.

Balancing planes are hinged between the extremities of the main planes, as in the Cody machine. The wheels on the fuselage are specially designed to be lifted up above the skids at will, thus providing a brake for the machine, and avoiding any risk of wheel buckling when landing. Controls are operated by a single pillar, a forward and backward movement of which operates the elevator, a sideways rocking moves the balancers, and a turn of the wheel operates the three vertical rudders at the rear. The machine has only rudders at its tail, and no horizontal plane.

It has flown well, and is very strongly built. It is quite an attractive-looking machine. A novel feature is shown in the construction of the main planes, which are built in three sections, so that they can be folded back at either side in order to take up less room for stowing away.

Messrs. Short Bros. are well-known builders of British biplanes. They are the agents, too, for the famous Wright machines in England, but it is with their own type of machine that we must deal here. A representative example of their work is the Short biplane. It has nothing particularly striking about it in its appearance, but is a useful machine. Two planes, of 30 feet span, form the main supporting surfaces, stayed with the usual wires and mounted upon a two-wheeled chassis, fitted with stout, short skids. A single elevator is carried well forward. A 60 h.p. Green motor occupies the centre of the machine, driving a two-bladed propeller, and the tail is behind this. It is of light construction, big hoops keeping the

rudder off the ground in place of the more usual skids or wheels. The rudder is situated beneath a horizontal plane, and is square. The main planes are provided with ailerons for stabilising purposes, and the machine has a light and neat appearance.

Among British biplanes not so well known is the Twining, which has certain claims to novelty. It consists of the ordinary two planes, the upper straight, and the lower curved at a slight dihedral angle, mounted on a strong, broad-based, four-wheel chassis. A biplane elevator is carried forward, and the rectangular, twin rudder planes are in the rear. A further horizontal plane is carried in the tail behind the two-bladed propeller. The balancing arrangements consist of two small planes placed midway between the ends of the main planes. They are hinged in the centre and can be turned independently at varying angles, according to the will of the pilot, in any position from the vertical to the horizontal.

There are various other British biplanes in existence. At the time of writing the Roe biplane is coming to the fore—a biplane with a tractor screw, warping wings, no forward elevator, and a cruciform tail. This machine has made some excellent flights at Brooklands, winning the duration prize with a flight of an hour and a half in very gusty weather on Easter Monday, 1911, under the piloting of Mr. Pixton. Many of the other machines that I have not attempted to describe are adaptations of Continental types, or are purely experimental. Many have only made short flights. Some are unfinished. It is un-

necessary to deal with these, and the only other machine I shall mention before leaving the modern aeroplane and considering other aspects of flight, is the Roe triplane, known as the Avroplane.

This machine has three main supporting surfaces, the two upper ones of equal span, and the lowest considerably shorter. It is driven by a tractor propeller. The enclosed body in which the engine and pilot's seat are mounted is fixed just below the middle plane, the pilot sitting right behind the machine. A light girder frame tapers back to the rear, where a pigeon-shaped tail is fitted, consisting of a horizontal plane, with two elevators at the back, and a vertical rudder. The machine is mounted on a chassis of two skids, and two pairs of wheels, and is controlled by the pushing or pulling of a lever, which operates the elevator, a twisting of a wheel which warps the upper planes, and the movement of a pivoted bar, swinging the rudder. This aeroplane has made good flights, but very probably the Roe biplane will put it in the shade.

With this I must end my description of some of the well-known British machines. Many of them are thoroughly efficient, and are capable of equalling the feats of any Continental machines. And as they develop there is no reason why they should not give us the power of ruling the air, just as the building of fine battleships has enabled us for so many years to rule the sea.

CHAPTER XIV

In the Pilot's Seat

HAVING now considered various types of aeroplane from the spectator's point of view, it behoves us, if we are to improve our acquaintance with the machines, to inspect them from the pilot's seat, to watch the airman at his work in mid-air, and to learn something of the qualities which should go to the making of a great flying man. First of all, therefore, it would be well to study the methods by which flight is taught.

The captain of a ship has to pass stiff theoretical examinations in navigation. So, if he is to be a thorough all-round man, the air-pilot must understand the theory of the machine that he is to con through the air. He must have a knowledge of aerodynamics, and of the whys and wherefores of flight. This is quite obviously a necessity if he is to appreciate fully the capabilities of the aeroplane, though he need not, of course, go into the involved mathematics of flight. A knowledge of propeller thrusts, stresses, strains and so forth will be useful, however, and if he is a keen man he will probably not rest until he has acquired such knowledge.

Then, too, the air pilot should be a practical man. The man who drives a motor ought to understand something of his machine, of the mechanical

principles on which it is built, and of its actual working. He should be able to find faults, to rectify and adjust them with the certainty of the skilled mechanic, or even of the more advanced engineer, if he is to be an ideal pilot. Such a knowledge is of inestimable use in the case of his alighting at a spot where skilled mechanics are scarce, and the ability to use tools in an intelligent and handy way is worth more than gold.

Then again he should have a full knowledge of the way in which the aeroplane is constructed. He should be able himself to make small repairs and to direct others in the way to make more serious alterations and adjustments, should damage result in consequence of a rough landing. He must, above all, be thorough, hawk-eyed, who will certainly pick out any weak point, any slack adjustment of wire or looseness of screw; and it would not be a bad thing if every pilot were compelled to put in a certain amount of his time in working through a construction course at an aeroplane works. Air-scouts in particular should be able to make small repairs with technical skill.

Thus primed with the theory of flight and a knowledge of engine and machine, the pilot can turn to practical flying.

Flying, like cycling, is largely a matter of confidence and experience—particularly the latter. The Wrights, it will be remembered, fully appreciated this fact when they made their early gliding experiments before trusting themselves to a motor-driven biplane. For this reason the system followed in teaching flying is eminently

practical. As a rule, the pilot is first taken out with his teacher for "rolling practice." This is equivalent to the land exercise that is sometimes taken by the would-be swimmer before he attempts to make use of his strokes in actual water. The aeroplane is allowed to trundle along the ground, and attention is given to the operation of the rudder, the general "feel" of the plane, and the position of the controls—varying, as you have seen, on different types of machine.

Following this initiatory stage comes the hopping period. During this time the pupil, under the instruction of the watchful pilot, begins to operate his elevating planes, rising from the ground for short jumps more than for actual flight, and bringing the machine quickly to earth again, care being taken to avoid rough or steep landing. The feel of the aeroplane in flight thus gives the pupil confidence, and when at length his instructor takes him aloft for extended trips he is better able to give his attention to the immediate business of controlling the aeroplane aloft. He is now allowed to hold the various levers for himself, to experience the sensation of guiding the aeroplane, and to feel the behaviour of the machine in gusts of wind, or when turning. At first his hands are more or less "guided" on the controls. But soon, if he is an able pupil, he will take the levers under his sole control, while his instructor sits beside him, and little by little will master the essential parts of plain flying—simple turns, gentle descents, and so on.

He must learn to make the *vol plané*, or glide,

descending at a gentle angle straight to earth, and making sure of his ability to con the machine to a fairly restricted area of ground. For it has frequently happened that an airman has under- or over-shot his mark, and found himself in difficulties as he comes down at a steep angle, straight for a wall or a hangar, as the airship garages are called. The higher degree of skill in managing the *vol plané* the greater the degree of security in case of accident aloft. Should his engine start misfiring badly, or stop, when he is at a high altitude, the pilot will have to descend at once, to avoid a vertical fall, taking the opportunity of gliding down while there is still enough speed on his machine. In such a case, if he is over a densely wooded or populated country, the ability to bring his aeroplane to any clear space within reach may save his life. He may, too, have to perform his *vol plané* against a head wind, a feat which is tricky and dangerous, as Mr. Grahame-White has testified in a subsequent chapter. Then, of course, he must know his controls so well that their operation—the twisting of a wheel or the moving of a lever—become instinctive; and he must, above all things, never hesitate when in mid-air. Neither must be make mistakes. On a motor, unless travelling at a terrific speed, you can as a rule rectify a slight error of judgment before harm is done. But in the aeroplane, once warp the wrong wing, or depress the wrong aileron, and the earth will be rushing up to meet you before there is a chance of recovery.

Many beginners have accidents through faulty landing. They come down to earth at too steep an angle, fail to right the machine, and crash heavily on the fore part of the chassis, smashing wheels, skids and planes, and running dangerous risks of injury to themselves. The novice has to devote a deal of attention to the art of alighting gently on ground which is not always level. Here big skids will often save him from disaster.

It is a peculiar fact that in flying the right-hand turn is often found difficult. This is particularly the case with a rotary engine, and it is one of the hardest nuts which the learner has to crack, the left-hand turn being far easier. Eventually, however, under a good instructor at any of the well-known schools, the beginner will conquer difficulties and find himself really flying efficiently.

Then he begins to know the joys of aviation. The roar of the engine behind him, the jolting as he rolls forward, released by the straining mechanics, the lifting force beneath him and the rush of wind in his face. And then the peaceful soaring up and up, with the earth dropping backwards beneath him, and the landscape broadening out on each side as he drives higher and higher towards the clouds. Now and again the plane rolls or dips slightly, but without the sickening pause and jerk attending the motion of a boat on a choppy sea. A gust catches the wings, and the biplane banks over. The pilot's hands move instinctively on the lever or wheel, and maybe he sways sideways himself. Steadily and surely,

as the aileron on the dropping side comes into action, increasing the resistance, the plane levels and rights itself.

Glancing around him, if he be upon a biplane, the aviator sees, on either side, the sweep of the planes—one at his own level snowy white and one, translucently yellowish, above his head. All about him are shimmering wires, as though a great spider had been at work among the varnished spars which support the planes. Behind him is his engine, the screw a mere circular shadow as it races round, and beyond that again are the tail and the white rudder. Looking to the front, he sees the outrigger spars, bright yellow and shining, running to a peak where the elevator plane is fastened, and beneath that and below his feet the houses and green fields sailing backwards, with now and again a startled bird "tweeting" past as it hurries from the proximity of this deep-throated, mysterious rival.

If the pilot be upon one of the latest machines, a Blériot monoplane or a Bristol military biplane, he will be seated comfortably in a padded bucket-seat. Before him will be a desk, with a map beneath a glass case—a map running on rollers, which can be turned forward as he crosses the country mapped on each visible section. Within easy reach are dials, instruments, gauges and a compass. Every scrap of brasswork is polished, heliographing stray sunbeams as the machine moves.

The airman alters his controls and begins to rush round in a wide curve. Now his machine

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is banking steeply, swinging along the edge of the arc at high speed. A moment of whistling wind and rushing exhilaration and the turn is accomplished. Now the landing place is dead ahead. The pilot throttles down his engine and depresses his elevator by the movement of the lever before him; and then, sliding forward swiftly and smoothly, he drops in one delicious glide and comes to rest softly on the turf, his flight over.

During such a run as this the pilot has met with no unexpected crises. He has had no rain, save for a splash or two of oil, to dash over him and rattle on the planes, no wild gusts to tip or wrench his machine, and no unforeseen down currents or treacherous air pockets to bring him to earth.

But he must be prepared for such eventualities. He must be cool and possessed of steady nerves. Then, too, it is entirely necessary, both for scouting and for ordinary cross-country flying, that he should be able to read his compass and steer by it and should be able to follow his direction properly on the map. The importance of steering a course by an efficient compass was well illustrated by the deplorable disaster which overtook one of the most brilliant and sportsmanlike young airmen in England, Mr. Cecil Grace, on December 22nd, 1910.

He was flying for the De Forest prize, it will be remembered, using a Short biplane. At half-past nine on the morning of December 22nd he left Dover, bound for the Continent, in rather foggy weather, followed, as he headed across Channel, by tugs. About noon he landed safely at Les Baraques, near Calais, a contrary breeze having

sprung up. After lunching at Calais, he made up his mind to fly back to Dover, in order not to miss a chance of starting for the prize on the following day. The mist had cleared slightly by this time, and shortly after two o'clock Mr. Grace left the ground on his return flight.

Soon after he got away from the French coast his machine vanished in the mist, but was sighted by the tugs, flying well on the proper course for the English coast at Dover. At Ramsgate his aeroplane was made out by coastguards, well out to sea, and apparently heading northwards over the Goodwin Sands, instead of inland. By that time some alarm was felt at the fact that no news of his arrival had been heard, and swift motors set out along the coast, their drivers hoping against hope that the rapidly thickening winter fog, which was lying heavily over the sea and disorganising shipping in the Thames, had not involved the airman in difficulties. But no welcome news came, and hope, which was kept alive for some days, gradually died. Somewhere out in the North Sea, lost in the fog, out of sight of land and shipping, the aeroplane had fallen and sunk. Subsequently the airman's goggles were picked up, but of him and his machine nothing was found. It was a disaster of the most regrettable description, and Mr. Grace was universally mourned by airmen. He was one of England's most promising and popular pilots.

Such an accident as this, followed, as it has been, by sundry slight mishaps where airmen have lost their bearings in fog, points directly to the

importance of possessing an efficient compass for aerial travel, and to the necessity of steering correctly by it.

The pilot must also understand the unwritten law of the air. He must be careful not to get into the "backwash" of another man's propeller, or by culpable manœuvring to give another man his own backwash, for that way disaster comes.

If the pilot is to go in for army scouting work he will, of course, have to know something of military topography. As a rule, of course, scouts used for military work are officers, trained to observe such facts as may be necessary and helpful for their commanding officers. The novice cannot make these observations with a proper sense of the importance to be given to various points, unless he understands a good deal about military work. He should be able to estimate numbers at a glance with reasonable accuracy—a task which is by no means easy. When passing over artillery he should be able to see whether their dispositions are more or less permanent, or whether they are merely temporary resting places. He must recognise lines of communication, pick out positions which threaten his own force in any way. During some manœuvres conducted by the German Army air scouts were deceived by dummy trenches, and defences built up for their own special benefit. Flying high over these, at a good pace, they failed to discover that these were spurious fortifications, with the result that their work was not so successful as that which was carried out by the French Army airmen, the accuracy of whose observations

forced one general to change the whole scheme of his manœuvres.

It can be seen then, that if he is to be a perfect airman the man in the pilot's seat should possess a deal of knowledge of one sort or another.

In practice, of course, such knowledge comes by experience. The more a man flies the more he learns, and the first steps in flight are comparatively easy, many pupils taking out their machines alone in an astonishingly short time from the beginning of their instruction course, though it is some time before they indulge in "trick" flying, which is often condemned by airmen as being foolhardy and useless.

A machine to make learning a still easier and safer matter has been patented by Captain Sanders, of the Sanders Aeroplane Co. This is known as the Sanders Teacher, and is of service in giving pupils a good idea of a machine's behaviour in mid-air, without making it necessary for him to leave the ground. He can thus start learning the feel of a machine right away, without being accompanied by a pilot.

The invention is ingenious. It consists of certain essential portions of the Sanders Aeroplane, which I have already described, mounted on a wide framework. Seated in the pilot's position, the pupil finds a steering wheel before his hands, a rudder behind him, a biplane elevator in front, and on either side, mounted on horizontal rods, an aileron. He thus has all the controls dealing with flying, apart from the engine switches, ready to his hand. The machine is mounted on a pivot

and can be swung round in any direction, so as to bring it at any desired angle to the wind, and by this means the learner can "get the hang" of the aeroplane, so that when he goes aloft the feel of it is not entirely strange. Other teaching machines of a rather similar character are in use on the Continent. They are useful in giving initial confidence.

At the last aeroplane exhibition at Olympia there was a stand containing medical apparatus; and in a technical manual for airmen, published by the proprietors of the aerial paper *Flight*, there is a chapter devoted to "First Aid." It must be confessed that in such a connection this sounds rather ominous. Yet the motto of the Baden-Powell Scouts—"Be prepared"—is an excellent one for the airman, and it is an unfortunate fact that accidents will happen at times. Bearing this in mind, the pilot will be a wise man if he gets some sound knowledge at least of simple First Aid, for, as many people can testify, efficient help at the right moment may do a great deal towards facilitating the healing of a wound, or preventing it from becoming worse and more painful. An airman, landing badly in an out of the way spot, may have to treat himself and his passenger for sprains or cuts before help arrives. Recognising this fact, quite a number of airmen take up small medical outfits with them on their long journeys, and at Olympia a First Aid case was displayed, strapped on to one of the machines close to the pilot's seat in readiness for emergencies.

In this chapter I have attempted to deal with

flight from the point of view of the man in the pilot's seat. The actual method of control was covered in the chapters on the aeroplane. It is evident that the pilot should be a man of strong nerve, ready resource and common sense. Physically he should be wiry, able to stand a prolonged strain, and preferably blessed with keen sight.

These qualities are possessed by most aviators, and after they have gone through their learner's course, their skill is pretty thoroughly tested before the Royal Aero Club grants them their pilot's certificates. From the pages of *Flight* I have taken the following statement of the conditions that have to be fulfilled by the candidate for a certificate. It is possible, of course, that they will be altered in the future. But they are interesting at present as showing what is required of the modern aviator before he becomes a recognised pilot, emerging from the chrysalis of "pupildom" into the form of a full-grown flying man. The conditions are all the more interesting when we remember that a little time ago it would have been considered impossible for any man ever to fulfil them! Now they are merely the test from which, having passed, the pilot goes on to greater things. They are as follows:

"The Royal Aero Club of the United Kingdom will grant certificates in accordance with the regulations of the Fédération Aéronautique Internationale to candidates who have complied with the following rules:

1. Candidates must accomplish the three following tests:

A. Two distance flights, consisting of at least 5 kilometres (3 miles 185 yards), each in a closed circuit, the distance to be measured as described below.

B. One altitude flight, consisting of a minimum height of 50 metres (164 feet), but this must not form part of one of the two flights prescribed above.

2. The course on which the aviator accomplishes tests A must be marked out by two posts, situated not more than 500 metres (547 yards) apart.

3. After each turn round one of the posts, the aviator must change the direction when going round the second post, so that the circuit will consist of an uninterrupted series of five figures of 8.

4. The distance flown shall be reckoned as if in a straight line from post to post.

5. The method of alighting for each of the three flights shall be with the motor stopped at or before the moment of touching the ground, and the aeroplane must come to rest within a distance of 50 metres from a point indicated previously by the candidate. The landing must be effected under normal conditions, and the officials must report the manner in which it was effected.

* * * * * *

7. All flights must be made between sunrise and sunset. . . ."

Such are the regulations relating to the actual flights, though there are other rules referring to

the expenses, and the flying of foreigners, etc. It will be seen that the pilot's certificate is well earned.

It speaks well for the efficiency of the aeroplane that pupil after pupil is passing these tests; and if anyone scoffs at the aeroplane—and there are still strange people who do so—it is a good answer to all their arguments to quote to them the conditions of the pilot's test, without the possession of which the airman is not officially recognised. If the objector is still not convinced, my readers had better leave him alone. You cannot drive nails into toughened steel, nor plain facts into certain kinds of brain!

CHAPTER XV

A Talk with a British Airman

IN common with the tendency of the public to decry British machines, there is also a distinct inclination on the part of the " man in the street " to look upon British airmen as inferior to the pilots of Continental fame. This is an entirely unjustified and little-spirited attitude, for there are many first-class British pilots who can hold their own with any man from abroad. It is impossible to mention many names, because even as I write new men are working for their certificates, and by the time this book appears new names may be famous. Still, such men as Messrs. Moore Brabazon, Graham Gilmour, Alec Ogilvie, S. F. Cody, T. Sopwith, Armstrong Drexel, Captain Bertram Dickson and others are all first-class pilots, while the late Hon. C. S. Rolls and Mr. Cecil Grace were splendid flyers. But among British airmen I expect no name springs more readily to my readers' minds than that of Mr. Claude Grahame-White. Our most famous pilot, his work is as well known on the Continent as it is in England, and in America he established his reputation by winning the Gordon Bennett Cup in 1910. His name first became a household one here when he made his fine attempt to win the London to Manchester race. But since that

time he has made many fine flights, and has spared no trouble to further the art of aviation in England.

This is only to be expected, for he knows his aeroplane from the smallest screw to the engines, is vastly enthusiastic, and entertains the best hopes for the future of flying in the world. He understands the capabilities of the aeroplane from intimate experience, and foresees far more clearly than the most optimistic layman the developments to which it may lead us.

It is quite obvious that if flying machines can develop to a really great extent they will cause nothing less than a revolution in our modes of life. And it was with the idea of obtaining an experienced airman's opinion on this point, and also in connection with aviation generally, that I sought out Mr. Grahame-White, who very courteously granted me an interview.

It will probably be of interest to my readers to know that small model machines played an important part in turning Mr. Grahame-White's attention to aviation. In answer to questions he admitted that he had occupied a good deal of his spare time in constructing miniature machines before he thought seriously of taking charge of a full-sized aeroplane.

"I first began to take an interest in flight through the making of models," he said. "As a matter of fact, they were all on the helicopter principle, as it was my opinion at the time that the helicopter was the only machine likely to be of any use. I built model after model, scrapping one and starting another with great regularity,

until at length the aeroplane as we know it began to make itself heard of."

Previously to this, however, Mr. Grahame-White admitted that he had some experience of balloons.

"I made several ascents from the gasworks at Battersea, and I must remark that ballooning cannot compare as a sport with flying. It is neither as exciting, nor as pleasant. In a balloon one just drifts at the mercy of the wind. There is practically no opportunity of control, the aeronaut is more or less helpless, and the whole experience is very much less interesting than that of a flight on a power-driven, heavier-than-air machine."

"You have no sympathy with lighter-than-air contrivances, then?"

"None whatever. I have no sympathy in gas-bags of any description, and personally I do not believe there is any future before them. I would place no faith at all in airships, either of the rigid or non-rigid types, for various reasons. In the first place the machines are huge, cumbersome and clumsy, and their very size invites destruction. Then again, consider the difficulties of management on landing or on starting out. A small regiment of men is required to control them and to drag them to the necessary position. And if a gale should spring up, not even a regiment can save them from being destroyed, or at any rate badly damaged.

"Then, when they are in the air, the bulk that they present gives them a huge resistance to

overcome, and a strong headwind cripples them at once. In order to come to earth they must have a comparatively large stretch of open country within reach; while harbours of a cumbersome size must be constructed to house them. No, there is no comparison between the usefulness of the aeroplane and the gas-bag—the lighter-than-air machine."

This is an emphatic and earnest expression of faith. Neither is it an opinion to be ignored, and it is not to be supposed that a man holding these theories would have been contented for long with the tame amusement provided by the balloon. As soon as flight with heavier-than-air machines emerged from the country of dreams to that of hard fact, Mr. Grahame-White proceeded to France, and before long was learning the control of an aeroplane.

"I began with a Blériot monoplane. It was only when I had learnt the control of this machine that I went to work with the biplane."

Questioned as to which he preferred, he indicated that he had no particular preference.

"I like one machine for one purpose and one for another," he said. "And I do not think there is much difference in the piloting. The monoplane is more speedy? Oh, I do not think so—or, at any rate, it will not be so for long. It may be easier at present to get high speeds with the monoplane, but I think we shall very soon be able to fly just as fast with the biplane. While, as regards stability, there is nothing much to choose between the two types."

My readers doubtless know that Mr. Grahame-White is equally at home with either monoplane or biplane—Farman or Blériot—although his big effort for the Manchester flight was made on a Farman biplane.

I then asked questions concerning the difficulties of the pilot.

"There is really very little difficulty in flying," was the answer. "You may say that when you are driving a motor on a greasy road you must keep always on the alert, continually watching your machine. But, as a matter of fact, you know that there is no conscious effort involved.

"It is just the same with the aeroplane. Your piloting becomes instinctive. You make all the necessary motions without a thought, adjusting yourself and the machine together, as it were, to meet any unexpected gusts.

"Then, too, the stability of modern machines is very good. As the aeroplane develops it will doubtless become better and more perfect. As to the question of some invention giving you automatic stability, I don't think any particular work is likely to produce a machine that will do that. The stability will simply evolve, so to speak. The machine will go on improving in various ways, until one day we find that we have a machine that is perfectly stable, owing to a combination of various factors. Stability is so largely a question of the distribution of weight and so forth—and we have still a lot to learn in that connection.

"In this way, as new inventions improve the aeroplane, it will, of itself, become safer—

though, as a matter of fact, it is remarkably safe now, all things considered. As a rule it is only when trick-flying is attempted that smashes occur.

"At the end of 1910, as you will remember, there was a sudden rush of accidents, which were viewed rather pessimistically by the public. They were too inclined to put them down to the danger of the aeroplane itself. But I think there is no doubt whatever that public interest in aviation will increase tremendously as soon as people realise that a man is not necessarily risking his life when he takes a trip aloft.

"When you come to think of it, there are really marvellously few accidents. I believe there are about 4,000 men who actually fly at the present moment. Not all of them have pilot's certificates, of course, for there are many men who are using crude, undeveloped machines of their own design, men who have had no experience and very little tuition. When you remember this, the number of bad accidents that actually occur seems absurdly low. In any case, every new science of this description has to claim its toll in the beginning.

"The one great thing in flying is thoroughness. I know of no other sport or mode of locomotion in which this quality counts for so much. It is absolutely essential that the pilot should be thorough in every way. A single loose nut in the machine may cause his death, and he must therefore have his machine in charge of a good and reliable man, who can be trusted to overhaul it from end to end, and their owner and pilot must

be sufficiently well versed in the construction of the machine to verify every detail."

In answer to a further question, Mr. Grahame-White said that the wires did not give them much trouble.

"Of course they must be properly attended to, and care must be taken to see that they are not fraying or wearing through by constant friction. I have sometimes seen wires on my machines worn almost as thin as cotton, and it is just possible that the breaking of a wire might spell disaster. As a matter of fact, on the Farman we have a special system for providing against such an accident and its consequences.

"We employ what are known as pilot wires. Every wire in the machine is duplicated, but only one wire is kept tightly strained, the other, running beside it, being finger-tight. If then the taut wire snaps, the loose wire takes the strain and automatically tightens, whereas, if both wires were taut in the beginning, the snapping of one might equally well imply the snapping of the other. But in the future I think that wires will be entirely absent from the aeroplane."

"You think that the form of machine will change?"

"Absolutely. It is really impossible to say what the aeroplane of the future will be like in appearance. At the present day new types of machine are being evolved every month. New planes and new shapes of planes are all being tried with success. Anything seems to fly; you could make an orange-box fly, if you wanted to!

"This, of course, only shows that the aeroplane is in its first stages of development, and it will be some time before the best form of machine is developed."

"Are machines with a variable plane area going to be built?"

"I think so, certainly. You will have a large area of plane in order that the machine may start or land at slow speeds. And then, for fast travelling in mid-air, the plane-spread will be reduced. The idea can be applied to both monoplanes and biplanes—more easily to biplanes, in fact."

Mr. Grahame-White had already intimated that he had early felt an interest in the helicopter, and as there are so many people who affect to despise this type of machine, as being a wild dream of the novelist, I inquired whether he still believed that there was any future before it. His answer is of considerable interest, for it does, as a matter of fact, hint at the appearance of the aeroplane to come.

"I believe," he said, "that the helicopter principle will eventually be applied to the flying machine in conjunction with the present system of planes. As things are, the flying machine must keep in motion. But with an efficient helicopter there would be a possibility of producing a hovering machine that would be of the greatest service.

"But that is only one of the possible lines of development. All the while the modern machine is flying there is a big loss of power going on in various ways—from skin-friction and from the propeller. I believe that there is a very big

future for the propeller, and the discovery of the best type for use in the air will be of the utmost importance. It took a vast deal of experiment and calculation before a really suitable type of screw was evolved for marine use, and at present we know very little about aerial propellers. Certainly the present types always waste a deal of power through slip and other causes.

"The form of supporting surface will change also. Even now we are upsetting several theories by practical work. Not very long ago, for instance, it was thought essential that the entering edge of the planes should be thin. Practice has shown us now that a thickened entering edge gives us the best lift.

"Undoubtedly the engine will develop as well. In the early days of flight there was a craze for lightness—a craze which is now dying out, for we are learning new facts with regard to engine-power every day. Take this as an example—a year ago we could only lift two people with the same engine that we now use to lift five and even six. I think, therefore, that when engines have improved, we shall be able to do things that would have seemed wildly impossible a few months ago."

"Then you think there is a great future before the aeroplane?"

"Great? There is no limit to it! Think of the progress we have made since the London-Manchester flight. Just before that people never imagined that any flying machine could cover a hundred miles. Now they do 500 and more. It

is my firm opinion that in twenty years we shall have big aeroplanes, with a full complement of passengers, crossing from America to England with ease, at speeds of 200 miles an hour or so. It sounds a daring statement. But, thirty years ago, the suggestion that in 1910 we should have been able to get speeds of forty miles an hour on water would have been laughed at.

"Then there is no end to the uses of the aeroplane. It can be employed for exploration, and for war, to start with. I think that it is certain to be employed very freely in war, for instance."

There is one objection often raised by cynics to the aeroplane's use in war. It is that it would be impossible for a pilot to drop bombs from a moving aeroplane with any chance of hitting his target. I put forward this objection now, and it was met at once.

"I don't think," said Mr. Grahame-White, "that it would be possible for an aeroplane to drop one bomb on a battleship, say, from a height sufficient to keep it out of gun-range, with much chance of scoring a hit. But there is no need for the pilot to confine himself to one bomb. He would drop a series."

"In those circumstances, seeing that the aeroplane is so efficient, do you think that the Government ought to do more in the way of aerial work?"

"Yes, I think so. They seem to be waking up at last, though. As a nation we are certainly behind the French in the subject of aviation.

But I think that, as we always do, we shall creep up eventually, and there is no reason at all why we should not become their equals; and in the course of time I have little doubt that we shall obtain supremacy of the air."

This is a cheering statement, coming from the lips of an authority. And my readers must remember that, if history repeats itself, it is likely to be a true one. Years ago we were very behind hand in our knowledge and experience of the submarine boat. Nowadays the submarine service is one of the finest branches of the Navy. And this may equally well prove to be the case with aeroplanes, if proper encouragement is given to aviators. Touching upon this question, Mr. Grahame-White remarked that it would be a good thing if a great National Fund were organised for the purpose of aiding inventors to complete their machines. "Only," he added, "it would have to be managed by a very efficient committee, in order that help might not be given to every inventor who should come forward with wild and impossible ideas."

In spite of his successes and of his steady flying, Mr. Grahame-White has not escaped without his share of excitement in the air. Among other experiences, he has had the marvellous good fortune to escape with his life after a fall from a height of some 300 feet. This occurred during his early flights, and was the result of trying an experiment.

"I was flying all right," he said, "when I thought I would try a *vol plané* against a head-wind —a feat that had never previously been performed. No sooner had I started on the attempt, when

my machine began to lose way and at length dived downwards. I scarcely realised what was happening exactly, for I gave all my attention to righting the aeroplane. One never thinks of danger at such times. But I could not bring the machine up, and she crashed down and rolled over on top of me. I was pretty badly hurt—cut about, and naturally shaken up."

My readers will endorse the word "naturally." It was a wonderful escape from death.

On another occasion, when flying in America, Mr. Grahame-White found himself gliding down into a thick wood. His engine had stopped, and look as he would below him, he could see nothing save a thick mass of foliage, branches and tree-tops. It was an awkward situation, requiring the utmost nerve to face. But the pilot was not lacking in this quality, for, gazing about him, he espied at the last moment a clearing, into which he managed to bring his machine, saving it from a disastrous charge into the thick of spiked branches and unyielding timber.

So close were the tree trunks, in fact, that in order that Mr. Grahame-White might be able to fly safely on the following day it was necessary to requisition the services of over a hundred men to remove the aeroplane bodily, taking it over the trees on poles!

One other instance, which I will relate in my own words, suffices to show Mr. Grahame-White's pluck, if the famous Manchester flight was not sufficient to do so. This occurred during his successful flight for the Gordon Bennett Cup in America.

He was using a Blériot machine, the engine of which revolved in a framework which was rather a close fit. In the course of his flight for the Gordon Bennett Cup, a protruding piece of metal work caught the valve rods, and part of the framework was torn off, leaving a bare expanse of wood. Before long the heat of the exhaust gases caused this to smoulder, and, flying at a great speed as he was, Mr. Grahame-White began to think that there was every possibility of his machine catching fire, when it would have become a sort of blazing meteor at once, soaked with oil as it was.

Smoke from the lubricating oil and from the smouldering wood was puffing out all round the machine, hindering Mr. White's view of the ground beneath. He might very well be excused had he come down at once, all things being considered. But he did no such thing. He held steadfastly to his course, driving along at a great speed, and, as he was not certain whether he had finished the distance or not, actually stayed up in order to make two more circuits than were really necessary. It wanted more than the ordinary amount of nerve to do this on a machine which might at any moment have blazed up like a lighted wisp of flannelette.

Finally, I inquired whether flying was easy to learn, and Mr. Grahame-White replied that it was, provided that you did not try to do too much at once.

"And I repeat," he added, "that flying has a very great future before it."

There is very little doubt of this while we have such a keen pilot as Mr. Grahame-White to take charge of our machines. And it is good, too, to think that he is ably seconded by the many other men whose names are at the head of the British roll of aviators.

CHAPTER XVI

From Other Points of View

BEFORE leaving machines as they are to-day, we must briefly consider some other aspects of aviation arising from the interest taken in the new art by a small section of the public.

One of the most notable accompaniments to the increased skill in flight has been the opening of a number of flying grounds all over Europe. A few years ago the idea of preserving a large open space for the sole purpose of flying would have been considered the height of absurdity. Nowadays, however, in the green precincts of the New Forest, on the open rolling stretch of Salisbury Plain, at Sheppey, in London, at Weybridge and at numerous other places in England alone, are wide tracts of level ground reserved solely for the use of the flying men and their pupils. In France there are more flying grounds than can be counted on the fingers of the hands.

I suppose the most famous flying ground in England is that amid the pine woods of Weybridge, at the Brooklands motor track. A flying ground, to be good, should be level and open, not closely ringed by hills from which treacherous breezes can blow, or by thick forests which may make unpleasantly spiky landing places for airmen. Brooklands fulfils these conditions well, and on a typical

race day it presents one of the most up-to-date spectacles in England.

You walk in through the turnstiles past a margin of shrubberies and winding sandy paths, and passing beneath a stone tunnel, emerge close to a stand. As you round this the whole track lies before you, a great concrete ring, some three miles round, banked at a terrifically steep angle at the ends and of a titanic size. At the foot of the hill on which you stand are the garages for the motors. Beyond that is an oval stretch of open ground, over a mile broad, and in the far corner, close to the distant edge of the track, is a cluster of sheds, owned by the colony of airmen. Outside these, perhaps, two or three machines are lying glistening in the sun. Here is a Blériot monoplane, and in the distance you can see a little crowd of black figures clustered about it.

Then your attention is taken up by a sudden roaring as a motor race starts, and five or six mighty cars, black or grey, with huge bonnets and crouching drivers, begoggled and close capped, jump into their top speed, storm past you like cyclones, heading up the steep banking, are eclipsed for the moment by the stand, and reappear again, like flies creeping round a pie-dish, far away. The mutter of their progress only comes faintly to you now. Gradually it rises again as one of the cars finishes the lap, and banking steeply over leaps past at a hundred miles an hour or more! You have a glimpse of crouching driver and whale-like bonnet, and it is gone; and simultaneously a new sound strikes on

your ear. It is the roar of the motor, but sung with a deeper, snoring note, and glancing upwards you see, just rising from the background of pine woods, a white shape, which lifts gracefully, dips and swings up and up, resolving itself into the well-known form of a Blériot monoplane. "Up she goes!" There is a busy cluster round a Farman in one corner. Turning your glasses on the group you are in time to see the crowd of mechanics hanging grimly on to the machine, their coats fluttering in the draught made by the propeller. Another moment and they let go; the Farman trundles forward faster and faster, and then with a graceful lift she leaves the ground, and appears sailing up after her rival, to be followed herself by a British machine. And so the afternoon passes. Below, the giant motors snore round the track at speeds that are terrifying to watch. Above, the aeroplanes float round and round, now dipping and rolling, now gliding with perfect steadiness over the heads of the onlookers, or maybe over the railway line running to one side of the ground. Such is Brooklands, and during the week you may see pupils going through their paces there, or new machines under trial.

Brooklands is the most romantic flying ground of all, as the great motors lend to it such an up-to-date atmosphere. But the ground at the New Forest is a pretty one. That at Hendon is not particularly beautiful; but it is exceedingly useful, and that, after all, is the chief point and the quality most to be desired. Flying grounds are interesting as being the nurseries in which new machines and

new pilots make their début; and in addition, at many of the best-known grounds you can book passenger flights, the prices varying according to the distance flown, and the *vol plané* being looked upon as an extra tit-bit to be paid for specially.

Another consequence of the attainment of flight has been the creation of an aerial press. There are many aerial papers in existence now in Europe and America, some of these, as is the case with the English *Flight*, depending solely on aeroplane news and photographs for their reading matter. It speaks highly of the work done by airmen that week after week such journals are enabled to appear with fresh news and attractive photographs. In addition to the aerial papers there are also the weekly columns of aviation notes run by various journals; while the typical modern airman, in brown overalls and a smile, has made his appearance in fiction.

Photographers have begun to haunt flying grounds, and picture post-cards of airmen and machines have appeared on the bookstalls. Then, too, a familiar visitor to any ground is the cinematograph man, whom you may see frequently, turning the handle of his camera as he records the smiles and twinkles of the famous airman about to start upon a long flight. Subsequently the public are treated to glimpses of Mr. So and So tuning up his machine, or enjoying a joke before leaving the earth. And the aeroplane, too, has not infrequently formed one of the dramatic staff of a company of cinematograph actors, engaged in

performing a thrilling drama before the clicking camera.

Since the public, as I have remarked before, are rather apathetic concerning flight it is only natural that a determined attempt should be made to rouse their interest, and this is being done by various enthusiastic men who have delivered lantern lectures, dealing with the aeroplane and its performances, in various parts of the country.

Gliding clubs and aerial societies have sprung up like mushrooms all over England—some of them important organisations, with machines and a ground at their disposal, some of them only clubs for the purpose of experimenting with models and the reading of papers by the various members.

And it may be mentioned that one very useful movement has been started by a boys' school at Surbiton, which runs a most enthusiastic aerial club of its own. This club has done splendid work. Under thoroughly competent direction and guidance the boys have built some remarkably successful models; have constructed big kites, and a full size glider; and have held exhibitions and flying meetings of their own, when several of the miniature machines have made wonderful flights. The boys have a library of aerial works at their disposal, and are very keen on the study of flight and its various questions. Their example might well be followed by other schools, for it is only by rousing public enthusiasm that we can ensure England taking the premier place in the air. And if my readers wish to do something to

impress the importance of the matter upon their more sleepy brethren they should lose no opportunity of joining clubs, societies or leagues.

Such are a few of the consequences of modern flight.

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CHAPTER XVII

The Future of Flight

PROPHECY is a dangerous game to play nowadays. My readers will probably remember the Delphic Oracles, who always made their prophecies ambiguous, so that, whatever happened, they could not be proved wrong! The priests who engineered those forecasts were wise men, and their example seems to be an attractive one in dealing with the question of flight.

Events move rapidly in these days. Four years ago, the man who prophesied that in 1910 an aeroplane would fly 300 miles would have been looked upon rather as a harmless lunatic than an earnest student of aviation. Yet this man, if he had kept his thoughts to himself, might have felt crestfallen when, at the appointed time, the flight was made, and he was thus unable to experience the joy of crowing over supercilious friends! Now, in 1911, we know that flight is an accomplished fact, that the aeroplane is a trustworthy machine, as yet only in its infancy, and that every day improvements are being made, old types scrapped and new standards taking their places. This being the case, and authoritative opinion being that the future of flight is limitless, we can at least let our thoughts wander ahead of the times and conjecture what the effect of the

aeroplane on the world will be, and what the machine will do, without being accused of undue recklessness of imagination. Let us look about first of all and see what clues we have at present to the future development of the aeroplane.

The first thing that strikes one is the unstable condition of the modern aeroplane—I do not mean unstable in balance, but in appearance. We have certain well-known types of machine. In the first days of flight these could be recognised by any layman with ready certainty. A clumsy-looking, box-kite machine was displayed before his eyes, and he knew that that was a Voisin biplane. Another was a Farman, another the familiar Wright. The different makes were so plainly standardised that it was quite an easy matter to name the machines in a composite photograph or a snap of a flight meeting.

Nowadays things have changed. Not only have scores of new machines made their appearance —flying well, too—but the standard types have been altered again and again. Changes have been made week by week—sometimes trivial to the eye, sometimes very great. The leopard may not be able to change his spots; but the Blériot monoplane can change its tail, the Wright biplane its elevator, the Farman its upper plane, and from the Voisin can spring a weird, tail-foremost "canard"! Alterations of various kinds are being continually made.

Inventors are working at new types of machine, scrapping failures, adding improved features. They are like artists making preliminary sketches for a

picture—rubbing out here, adding there. They are learning lessons by their failures, marking new trails to perfection by their successes, for others to follow; and, on the whole, all their alterations tend to simplify the machine. Maxim's first steam-driven aeroplane was decidedly complicated in appearance when compared with the clean lines of the modern Wright biplane. It is not at all unlikely that, when *every unnecessary feature* is eliminated from present types, the machine of to-day will compare in a similar manner with that of the future. Mr. Grahame-White has stated that wires, among other things, will vanish. He suggests that the machine will be of light wood. And when we remember that almost any machine made to-day will fly, however quaint its appearance, it is not unnatural to believe that, with the development of knowledge and the improvement of engines and propellers, a machine of the simplest description will grow out of the present chaos.

It is impossible to predict its future appearance, however. Perhaps the speedy monoplane will be gull-shaped, with widespreading wing-planes, of variable area, made to skim through head-winds and gusts at 150 miles an hour or more, as the torpedo-boat destroyer cuts her way through head seas. Maybe there will be a torpedo-shaped wind-house for the pilot, where all the controls will be housed. And when the stability question is settled, it may be unnecessary for the pilot to sit always with hands on lever. He may be able to pace his deck as the steamer captain paces

his bridge, while one of the crew stands by the steering wheel and another at the engines.

The bigger machines, not built perhaps for such high speed, may be biplanes or triplanes, with fair accommodation for passengers and crew, and engines that, though of small size, will develop the horse-power of a battleship's turbines, driving propellers of the maximum efficiency. Propellers are at present believed to be the channel through which a great deal of power ebbs away unused, and it is probable that the discovery of the really perfect aerial propeller will revolutionise flight. Of the appearance of the flying machine, then, we can say very little save in a general way. Of its use we can imagine many things.

War

In Tennyson's poem "Locksley Hall" occurs a well-known passage, prophetic of the development of flight, in which the writer says that he

> "Heard the heavens fill with shouting, and there rain'd a ghastly dew
> From the nations' airy navies, grappling in the central blue;
>
> Far along the world-wide whisper of the south-wind rushing warm,
> With the standards of the peoples plunging through the thunderstorm.
>
> Till the war drum throbbed no longer, and the battle flags were furl'd
> In the Parliament of Man, the Federation of the World."

In the lines that come immediately before these Tennyson refers to "Argosies of magic sails" carrying costly merchandise. Yet it is evident that the idea of flying machines as battle craft chiefly appealed to him—as indeed it appeals to most of us.

It seems to me that undoubtedly the most picturesque use of man's ability to fly is that connected with war, although in itself war is an unspeakably terrible thing. Despite this, however, inventors have not hesitated to put their machines and their brains at the service of military authorities in all countries, and it is certain that whenever the next great war takes place the aeroplane will play its part in the conflict—perhaps a big part, and perhaps quite a minor part. As a matter of fact, at the time of writing, the papers contain reports of aeroplane operations on the Mexican borders, in connection with the insurrection that is taking place there. In this case the machines have only been used for scouting, which, in fact, is the primary duty of the air-pilot in a modern war.

I do not know whether any of my readers have seen a "battle" at any big modern manœuvres of the Regular or Territorial forces. If they have, they will perhaps understand how vitally important accurate scouting is, for well-handled troops can be scattered over the countryside, behind hedges, walls, woods and hills, and so well hidden that an observer can scarcely believe that within a mile of him 20,000 men may be waiting for action. It is then almost impossible

for foot scouts to penetrate the enemy's screen of cavalry and outposts, in order to discover the dispositions of these waiting regiments, and yet accurate knowledge on this point may easily decide the victory. To the rescue of the perplexed staff-officers comes the air-pilot.

You will find him in the torpedo-shaped, wind-screened seat of a snowy aeroplane, lying like some gigantic butterfly in cover, behind a hill. A passenger in the uniform of an officer will sit at his side, armed with field-glasses. Before him will be a desk, holding a map and drawing instruments, while within easy reach will lie the transmitting instrument of the wireless telegraphy apparatus. From the distance, perhaps, battalions of khaki-clad infantry, waiting for the order to advance, will eye him curiously.

To this pilot comes a galloping messenger, despatched by the Staff, with orders which will send the aeroplane skimming aloft on its task of reconnoitring the silent countryside beyond the hill; and simultaneously the privates of the Air-Battalion spring to their feet and prepare to start the engine and hold the aeroplane, preparatory to sending it on its journey. A brief word of explanation, a moment in which heads are bent over the map, and pencils trace lines here and there! Then the officer nods, the pilot grips his levers, and a sergeant twirls the great propeller, till with a roar, and a smoking blast of air, it races round so rapidly that the eye sees only a blur. A moment's straining at the aeroplane. Then—"Let go!" and it darts off, rises gently, and heads

up and up, circling out towards the enemy's lines at a giddy height, with the sun shining on the planes, while the officer raises his glasses to his eyes. In a few minutes the aeroplane will be over the enemy. Positions will lie below, plainly to be seen. Maybe one or two of the special guns designed for the purpose will come into action with a quick, decisive flashing and thudding. But the aeroplane will be remarkably hard to hit. Apart from the fact that it presents a small target moving at, perhaps, sixty miles to the hour, it must also be remembered that it will be exceedingly difficult to find the range—and moreover, in order to frustrate the attempts to hit him, the pilot will probably alter his elevation continually.

It is quite improbable that any shell will find him, and meanwhile the keen eyes of the man at his side will be watching the lines below, searching woods and fields, marking here and there on his map, and then tapping messages of the utmost importance on his crackling wireless instrument—messages which, somewhere below, the staff are receiving, as they prepare their plans of attack. An hour later maybe the attack will be launched at those points where the enemy's line is known to be weak, and the air-pilot's work will have its result. This picture is no exaggeration, for in the French Army manœuvres of 1910 exactly similar work was carried out with the most successful results.

Another way in which aeroplanes will be of use will be in attacks upon "lines of communication." The lines by means of which an army receives

food, stores and reinforcements from its base are the key to its position. Once destroy the railway behind it, and disorganise the transport, and the army will starve and run out of ammunition. To attack this important point, it will be necessary to employ a number of aeroplanes, carrying explosives and manned by daring pilots. The fleet will fly well over the firing lines and the main army, and circling to their rear will distribute a liberal supply of dynamite bombs among transport wagons, convoys, bridges, and railway junctions, destroying on the way, wherever possible, the enemy's artillery and ammunition.

This will be a difficult task, without a doubt, for the effects of bombs have been considerably overestimated, the highest and most powerful explosives not accomplishing a tithe of the damage which might be expected of them. Still, daring and careful men, with plenty of ammunition and maybe some specially adapted bomb-releaser, which will enable explosives to be dropped accurately upon any place below, could undoubtedly do a considerable amount of damage, while the continued presence of these aerial destroyers, throbbing overhead and raining flashing and tumultuous death below, would probably affect the spirits of the troops adversely, more especially as their only defence would be to take cover. As I have said, it is probable that only chance shots would strike home.

Still, scouting will probably be the chief duty of the aeroplane in war. An example of the extreme importance of this duty is supplied by an

instance which occurred in the Russo-Japanese War. The Japanese had stationed a tremendous force of artillery on one side of a river, opposing a Russian position which was to be attacked on the following day. The artillery was planted among thick undergrowth, but the Russians located the position in the afternoon, found the range and made preparations to pour a terrific fire upon it as soon as dawn broke, and so silence the Japanese guns.

As it happened, however, the Japanese well knew that the Russians would attempt this, and during the night they not only moved their batteries several hundred yards farther back, but also transplanted the shrubs and carried them to the rear, so that in the morning from the Russian lines their position presented the same appearance as on the previous day. The Russians opened fire, using the ranges that they had already found, and their shells dropped short, while the Japanese artillerymen worked in comparative safety. Had aeroplanes reconnoitred this position, the cute move would have been discovered, and the Russians would have simply altered the ranges.

In naval war, also, the aeroplane may be of great use. Carrying a number of Curtisses or other machines, which can rise from the water into the air, a fleet might attack a big naval harbour with considerably more success than is possible under the present conditions. The attacking fleet would steam up and down at long range, hurling shell at the forts in the distance, and making no attempts to close for the time

being. Meanwhile, like a cloud of dragon-flies, the aeroplanes would spring into the air, carrying explosives, and heading straight for the port, at a big altitude. These explosives they could drop vertically from above on to guns, and, most important of all, on to docks, storehouses and ships under repair. And though here again the effects of explosives on the forts might not be as great as is expected, still a continual rain of dynamite from a fleet of perhaps a score of 'planes would undoubtedly cause some commotion. The only thing that would be likely to upset aeroplane work of this description would be weather. But aeroplanes are becoming more and more efficient, and pilots more confident, so that before very long only a gale or a heavy thunderstorm will discourage aerial operations. I was talking with a sailor not long ago. His comment on the future was interesting. "What with submarines below and aeroplanes above, a sailor's life will be a dog's existence," he remarked. Probably he is not far wrong.

In the case of a naval battle, for instance, the fleet which would liberate from its decks a cloud of aeroplanes would undoubtedly hold a big advantage over the fleet fighting only with guns and torpedoes. Probably the aeroplanes would search out the ship that was partially disabled and steaming at slow speed. They would drive after her like wasps. One or two 'planes might be hit by chance shots, or shivered by the blast of heavy explosives. The others would overhaul the wounded craft, fly directly over her and release a devastating stream

of bombs sufficient to destroy upper-works and quick-firing guns, and fire-control stations and possibly jam barbettes and turrets, and render the heavy guns useless. And it must be remembered that the experiment of launching an aeroplane from a warship's deck, and receiving it back again after a flight, has already been accomplished successfully in America. The "mother"-vessels for aeroplanes might be specially constructed cruisers, and need not of necessity enter the firing line, where they would run the risk of being sent to the bottom. They could steam behind in safety, waiting for their aeroplanes to rejoin them. The pilots, of course, would have to be daring men, but courage is not hard to discover among seamen, as a rule.

It is probable that it will be possible to use aeroplanes in this way in a very short time; and as they develop they will have a wide range of action, be more easily handled, and will become correspondingly more dangerous. When bomb-droppers and explosives are further improved for aerial use, the aeroplane will be a nightmare foe to tackle.

So far, however, I have only dealt with aeroplanes unmolested save by fire from below. As a general rule, though, if one side has aeroplanes at its disposal the other side will have them also; and then, before either aerial fleet can accomplish much in the way of destruction or reconnoitring, it will be necessary for one fleet to be destroyed.

It will be a heroic and terrible duel indeed—that fought by aeroplane *v.* aeroplane. Let us

consider how one machine will attack another. It is obvious, at any rate, that ramming will be of no use, because that will only end in the destruction of ramming and rammed craft, and save as a desperate resort that method is not likely to be practised for obvious reasons. It is all very well to knock your opponent out, but you don't want to break your own leg in doing it! It is possible that some kind of pneumatic gun may be carried, firing small shell, which will be employed at close range. But there again both sides risk destruction in an equal degree as they draw within range; and since in aerial fighting destruction must mean certain death, I imagine that pilots, however plucky, will run as few risks as possible.

The most probable way of fighting seems to me to be that pursued by the hawk as he broods over his prey. The victorious aeroplane will be that which is manœuvred to pass directly over the machine it is attacking, so that a bomb of comparatively small power can be dropped on planes or engines. It will not require much of an explosion to tear a fatal rent in the planes, or to upset the stability of the aeroplane attacked, while the machine above, save for the momentary jerk caused by the "backwash" of the explosion, will be unharmed.

So that you can imagine two aeroplanes rising to battle beneath the clouds, above, say, a great harbour. Circling and swinging round at their best speed, like great gulls, they will draw closer, now and again performing rapid figure of eight turns, maybe, as danger seems to threaten,

and perhaps exchanging rifle shots. Up and up they will go, perhaps into the clouds, where the driving white mists will hide one from the other until, plunging out into dazzling sunshine, they find that they are still near neighbours; higher and higher, with the wind howling past the shields and wailing in the wires, and the screws buzzing round at their best speed. Now one rises a little higher than its enemy. The pilot lets his engines all out, and banking over as it turns, the aeroplane swings round after its prey, and two great shadows chase each other over the silvery cloud pack below. Then the other machine rises, and the manœuvres are repeated, at a higher altitude, each pilot strained and desperate, knowing that an attempt to retreat, or the failure of his engines, must mean death.

At last superior manœuvring, or luck, must give one machine the awaited opportunity. For a second its shadow will hover above the machine below, and something will drop from the bomb-chute. A blinding flash and a cry—and those on earth will shout and point as a flaming meteor bursts from the clouds and hurtles earthward. A few minutes later the surviving machine will appear, making a *vol plané*, unhurt, and you can imagine the eagerness with which glasses will be levelled at it to discover its identity, should the opposing types have been somewhat alike. Such, in all probability, will be the aeroplane *v.* aeroplane duel.

But we have not yet considered the airships. To tell the truth, the more one considers the point,

the more certain it seems that airships are never likely to be of any use at all in war, unless the aeroplane fleet of one side is previously annihilated! To start with, the bulk of the ship is a disadvantage. Not only does it necessitate a choice of calm weather for manœuvring, but it also means the presentation of a comparatively big target to the gunners below.

Then again, supposing the airship did sally out on a perfectly calm day, when none of the enemy's guns were about, fully armed with explosives and bent on destruction. She would have to be accompanied by a number of protecting aeroplanes, to be of any service. For what would happen to her if an enemy's aeroplane sighted her, marking her down as a goal of attack?

The airship can attain an altitude of only about 5,000 to 6,000 feet, and she is barely half as speedy as a fast aeroplane. She cannot hide, her manœuvring is clumsy, her means of defence—nil. If she is unattended by aeroplane consorts, she might decide, wisely, to drop, and if non-rigid, to deflate at once. Or she may try to hide in the cloud packs, and so throw her pursuer off the track. But failing that, if she is rigid, she can only run and hope for a lucky gust of wind, or a lack of petrol, to put the aeroplane creeping up so speedily astern out of action. It is unlikely that that gust will come, and rising to a height, beyond the range of rifle fire, the aeroplane will sweep above the mighty bulk sailing below and drop its deadly messengers—and then, with the framework or envelope ripped, and torn by explosion, good-bye

to airship and crew! If the aeroplane let loose some small petrol bomb, spiked so as to pierce the envelope of the craft below, the results would be too terrible to contemplate when the liquid fire was spattered in the inflammable atmosphere of hydrogen. No, it certainly seems to me that the building of these mighty craft, such as our naval airship, is a waste of time and money, for it seems improbable, in the opinion of various authorities, that the airship will develop in anything like the way in which the aeroplane has even now developed.

The airship can only be useful when all aeroplanes are smashed, and she is only liable to attack by gun-fire or by another airship. Airship *v.* airship, I should imagine, will be fought out on much the same lines as aeroplane *v.* aeroplane, though the manœuvring will be slower and the *finale* more spectacular!

But, if unthreatened by aeroplane attack, and lucky enough to avoid artillery fire—and it must be remembered that it is extremely difficult for guns to hit a moving object in the air—then indeed the airship may prove to be a terrible engine of destruction—not so much over armies or fleets as over dockyards or towns. Imagine a fleet of such mighty vessels hovering over London at its most populated part, dropping bombs here and bombs there, smashing St. Paul's, Westminster, the Tower and the railway stations. It would be like a boy dropping pebbles into a city of card houses—destruction and ruin on all sides, and panic to block the streets. It might be remarked, too, that with improved airships and under existing

conditions such an attack by Continental ships would not be impossible, since the War Office has at present comparatively few aeroplanes which could be at once commissioned for service in destroying the air fleet. It is not very likely to occur just yet, however, which is just as well for one's peace of mind, and when it does, our fleet of aeroplanes will probably give an excellent account of itself. The presence of a fleet of airships over a big naval station would probably prove unpleasant too. As for the suggestion that airships can detect from above the presence of submarines, Mr. Cody has stated that he finds this possible only under certain conditions—when the water is clear and the bottom undisturbed, so possibly the power of the airship in this direction is not so great as was at first supposed.

So that an airship fleet in action will probably be in a considerable state of anxiety lest, across the sunset to the west, there should suddenly drive a number of those threatening black shapes—like the Valkyries or war spirits of German legend, that spell at once "aeroplanes" and "defeat."

It seems to me, therefore, that in war, at least, the aeroplanes will have the major share of the work, and when, perhaps, a means of steering them and manœuvring them from the ground by wireless rays is perfected, turning them into literal aerial torpedoes, they will indeed become terrible engines of destruction—so terrible and powerful that their very existence may perhaps put an end to war, and thus do humanity the greatest service in history.

Meanwhile, however, as things are, war is by no means a scotched snake. And it behoves us, as a nation, to realise the great powers of the aeroplane, and its use in war, or to insist that Admiralty and War Office not only train enough men, but build enough machines to give us the mastery of the air. Who knows that aeroplanes may not be found more useful than battleships in the near future? And they are far less expensive and far more quickly made, while hundreds could be housed on our coasts, ready for work, for less expenditure than goes to the upkeep of a fleet of torpedo-boats.

But men and money and enthusiasm we must have for this. We still appear to lack the enthusiasm, but by way of encouragement let us remember that, although at present France leads us, it is by no means impossible to catch her; while Germany, though paying considerable attention to aeroplanes, appears to be devoting a great deal of time to Zeppelins and such-like craft, and that, it seems to me, is a weak joint in her armour. In war aeroplanes are trumps every time!

Exploration

Another use for aerial craft, in the comparatively near future, will be found, I think, in connection with exploration of unstudied tracts of earth. Although, in these days, we are accustomed to talk rather thoughtlessly of the linking up of continents by rail and steam, and of the penetration of civilisation to every corner of

the earth, yet it must not be forgotten that there are, after all, considerable areas of land that no white man has yet set eyes on—land which may contain untold riches of gold or other metal.

There is a vast tract of unexplored country, forest, jungle and mountain, in New Guinea, for instance. Many attempts have been made to penetrate into this fastness, which is sentinelled by savage tribes and dangers of Nature's own making. But at present its secrets are well guarded. In Southern Arabia, again, in Thibet and Brazil, there are tracts of land which no men have yet mapped.

Maybe, when the airship is perfected, the great voyager of the skies, which seems to take second place in war, will be of vast use for exploration. Mr. Wellman, whose attempt to cross the Atlantic has been described fully earlier in this volume, made detailed plans and preparations for a voyage in his airship to the North Pole. For various reasons the voyage was not made, but in the future, if the airship is able to ride out a gale, and carry large supplies of food and fuel, there seems to be no reason why she should not be sent sailing above some of these unexplored regions, mapping, surveying, and landing hunting or ore-inspecting parties now and again. She might even carry a small aeroplane, which could be used for flying over fastnesses whither it was not thought advisable to pilot the ship.

Such work as this would be a benefit to mankind. It would certainly be romantic. But until the dirigible airship is improved in power

and in its capacity for staying aloft for long periods, exploration by air will be too adventurous, too hazardous to be undertaken on a large scale. It would be unpleasant to come to earth, short of petrol, in the midst of a tribe of New Guinea cannibals, whose fear might be but short-lived! But when flight is considerably advanced, there is no doubt that exploration by the "air-route" will be possible, and will be carried out.

The question of exploration suggests the making of maps, and incidentally it may be remarked that aviation will affect this branch of geographical work considerably. It will be necessary—and this before long—that the aviator should be provided with special maps, for the use of air-pilots only. A step in this direction has already been taken by France. On a map of the ordinary description will be placed special marks and signs, indicating the altitude of hills, steeples and woods, the surface of the ground—whether rough or suitable for a landing, the situation of aeroplane "garages," of flying grounds and repair shops, and the whereabouts of aeroplane or airship harbours. Thus aided, with special provision for rendering the identification of any particular town from above a comparatively easy matter, the air-pilot should have little difficulty in finding his way in any desired direction across-country.

Commerce, Smuggling and Passengers

One of the first uses to which railway and ship were put was the carrying of commercial products,

the transport of manufactures to and from towns and seaports, and one of the first objections raised to aeroplanes by the engineer is that it will never be strong enough to carry cargo. As to this there are varying opinions. If, as Mr. Grahame-White has said, aeroplanes will ere very many years be crossing the Atlantic with their complement of passengers, then it seems to me that there is no reason why they should not also be employed for carrying a certain amount of cargo—perishable stuff, possibly, which has to be conveyed across continents at high speed by the most direct route. Possibly certain quick mails will also be carried by air. But immense cargoes, such as might overload a *Mauretania* will still go by sea—in faster ships.

There is another side of " commerce," however, in which the aeroplane may, at any time now and in the future, play an important part. I refer to that branch which the old Preventive officers found so difficult to control—the smuggling branch.

In old times smuggling was, without a doubt, picturesque. A dark night with a sleek, black sea crashing on the beach beneath the cliffs and raking the shingle to and fro, loudly enough to cover the voices of the waiting boatmen; a squarish blot out to seaward, and then the flash of a lantern opened and shut; after that, casks trundled up through the salt surf, whispered orders, perhaps a hurried alarm and a pistol shot! That was smuggling in the true sense of the word—sneaking a cargo inland beneath the very noses of

H.M. Preventive officers. Nowadays smuggling is, for the most part, a matter of cigars tucked beneath waistcoats and diamonds hidden in hollow-soled boots—quite a decorous and unexciting pastime, with no romance or fighting attached to it.

With the arrival of the aeroplane, however, smuggling becomes both picturesque and risky once more. Saccharine, diamonds, lace, tobacco, spirits—all these could be carried in large quantities in the flying machine, and there is little doubt that bold men will find the risk of capture worth running. Once again, smuggling will probably be a matter of night work, of stealthy signals and wireless messages. The throbbing of a distant motor, an angular silhouette gliding overhead against the clouds, wheeling beneath the moon to some sequestered valley, and maybe a chase by the fast Customs monoplane, manned by two keen-eyed Navy men, who have caught the wireless message, and had their suspicions roused! On the Continent, where the frontiers are so strictly guarded, smuggling by aeroplane is already very possible; and even now, as I write, it is stated the Mexican frontier is being patrolled by two Wright aeroplanes to prevent the filibustering expeditions crossing—or, in other words, to check the smuggling of arms.

And perhaps, when commerce of value is carried aerially, some form of aerial buccaneering will terrorise the skies.

Then, of course, the aeroplane will be of use for passenger carrying, as soon as it has sufficiently

developed to tempt the average man aloft. The advantages of aeroplane travel are various. In the first place, the air, as a medium, is free from obstruction, and enormous saving in time and distance will be made, owing to the fact that it will be possible to travel, as the crow flies, from one point to another. There will be no necessity for transhipments or changes. The Paris aeroplane will start from London, and speed direct for its goal, at 100 miles an hour or more, so that its passengers will be under no compulsion to change at Dover or Calais. The journey will be an exhilarating one, giving a fine blow of fresh air, and a magnificent view of the surrounding country; so that express services to and from the Continent, and between various towns in England, will be well patronised when the safety of the aeroplane is an established fact.

The disadvantages of aerial travel are mostly due to the weather. Aerial disturbances are frequent and often of tremendous power, and this means that the passenger services will probably not run with the perfect regularity which is the boast of the big modern steamer companies. Then, if accidents should occur, the consequences would probably be disastrous in the extreme, while, at the start, at all events, it is probable that the initial cost of passenger service will be great. For these reasons I am rather inclined to believe that the arrival of the perfect aeroplane will give a great fillip to investigation into the mysteries of meteorology. Weather forcasts, telegraphed to every aeroplane station, will be

vastly more important than they are now—tucked away in some obscure corner of the daily newspaper. And if once a reasonable degree of accuracy can be attained in the prophesying of wind and weather three or four days ahead, the aerial voyage will be robbed of more than half its dangers.

As Seen from Below

Another point which we must consider is the effect that aeroplanes may have on the earth below.

One of the most notable changes will probably be in landscape. On various open spaces there will be aeroplane stations, and perhaps airship harbours—whole colonies of hangars, with repairing shops and petrol stores. Indeed, we can already see the beginning of this change in the establishment of the numerous flying grounds here and on the Continent. At present these are only used for tuition and passenger flights on a small scale, but it is nearly certain that they will develop into termini in the future, and that every large town will possess its aerial station. Wimbledon Common will be one starting place, Hendon another, and so on. While, if airships should continue to develop, and become more trustworthy and handy, the country may be dotted with wide, wind-sheltered pits into which they can drop for shelter. Arrows and marks may also be cut in the chalk soils by way of guide to the air pilot.

Then, as regards night-travelling, Germany already boasts of the first installation of electric-

light signs for the guidance of airships. In the future there is no doubt that the idea must be developed, and Mr. Rudyard Kipling, in one of his recent short stories, draws a fine picture of England "buoyed," so to speak, with great shafts of coloured light, shining vertically upward, through the clouds, flashing and changing:—"Coventry Central, the pivot of the English system, stabs upward once in ten seconds its spear of diamond light to the north; and a point or two off our starboard bow the Leek, the great cloud-breaker of St. David's Head, swings its unmistakable green twenty-five degrees each way." That is Mr. Kipling's conception of the night-signals of the future, and though it may be very many years before such lights are so far developed, there is no doubt that signals of some kind will have to be used as soon as night-flying is regularly indulged in.

Probably all the landmarks erected for the guidance of the pilot by day will be illuminated in a blaze of electric light, distinctly marked, so that no confusion can arise—a green square with a diagonal for one station, a white circle for another, and so on; while the harbours and bases themselves will be bathed in the glare of a hundred arc-lamps, making descent into their boundaries an easy matter. The great enemy of night travel, under these conditions, would be fog, which would wrap the signs in an impenetrable blanket.

It seems possible, too, that with the vast increase in the number of aeroplanes will come a great revival in certain trades. If wood should

be found to be the best material for the flying machine, carpenters and wood-workers will benefit considerably, while motor engineers should find plenty to do in the building of engines and in their improvement.

The rich will, in all probability, own their pleasure air yachts, just as they own steam yachts in these days, and travel will probably become very much more widely indulged in than it is at present. The result of this must be the broadening of knowledge and the closer knitting of nations. Probably, half the veiled hostility which is felt by one nation towards another is caused by lack of mutual acquaintance. In the old days, when we knew very little of the French, for instance, we professed a profound hatred and contempt for them, and in all probability they returned the compliment. Nowadays, when one thinks nothing of a trip to Paris, or Brittany, French Rugby football teams play in our own international matches—and do very well, too! So that, by bringing people closer together with direct and swift means of communication, the aeroplane may in the future do a great deal towards the creation of good feeling, even while its very powers are discouraging wars.

Another effect of aviation, which is already noticeable, and will certainly be increased in the future, is the legal effect. Aeroplanes will have to be considered by lawyers, and special regulations will have to be drawn up to deal with them. The dropping of any object from a flying machine may result in damage. The landing of a plane on

certain ground may rouse the wrath of the landowner. The noise of machines continually flying overhead may disturb an invalid, or upset a hospital ward. All these effects might be considered as "nuisances" and made controllable by the police. There must be a law of the air, too, as rigid as the navigation rules for sea traffic, drawn up by the Board of Trade. Aeroplanes must not pass one another so close as to cause upsets; probably, too, they will have to carry steering lamps and port and starboard lights when fleets of ships are regularly flying overhead.

In 1910 an Imperial Conference on Aerial Navigation met in Paris, and the question of International Aerial Law was at once brought forward. A most complete convention was drafted, making provisions for the registration of aeroplanes, certificates of fitness, and guarantees as to the capabilities of the pilot. It was decided, too, that, like ship captains, airmen must keep logs. From the pages of *Flight* I take the following extract:

"Dealing with the question of aerial vessels coming to land in foreign territories, the Conference agreed that they should be exempt from duty, and that provisions and working materials should enjoy the customary tolerance, while passengers' luggage should be treated as though it had arrived by way of a land or sea frontier. The carriage of merchandise can only be undertaken by virtue of special conventions or in virtue of international legislation. A noteworthy point is that the aerial transport of explosives, firearms, ammunition and carrier birds is prohibited; and

that of photographic apparatus is to be regulated by each State within its own territory. A State may cause the photographic negatives found on board an airship on coming to earth in its territory to be developed, and, if necessary, may seize them and the photographic apparatus. Wireless telegraphic apparatus, too, carried by an airship may not be used, without special permission, for other purpose than to secure the vessel's safety."

Other regulations were drawn up applying to military vessels. In the future, these regulations will certainly have to be enforced as stringently as maritime law is enforced to-day.

The aeroplane may also cause a big change in the conditions of life. Passenger services may become so frequent for longer journeys that the railways will degenerate more or less into goods-lines, save for a few trains and a big suburban service. The suburbs, too, will move right back into the country, the towns being simply the great work centres; and shopping will be done "by post."

A "back to the land movement" may well be encouraged by the perfection of the aeroplane. Garden cities of pleasure and beauty, well served by aerial machines, will form the living places of the country's population, which will hurry to work by air—save only for the poorer classes, who will probably live nearer to the towns, travelling by rail—probably electric trains. And the network of splendid main lines, which we take pride in to-day, may carry barely a fraction of the present number of passenger trains, but will vibrate all

day beneath the rushing passage of a fast goods service!

Such, I think, may be some of the changes wrought by the perfect aeroplane, the first studies of which we can see now. And as for the typical airman we can, perhaps, imagine him as a keen, clean-shaven man, with splendid sight and perfect nerves, and wirily built. He will be vastly weather-wise, full of technicalities concerning engines, propellers and planes; plucky, and ready to meet danger coolly and at an instant's notice. As he will not obtain a great amount of physical exercise during his day's work, I do not suppose he will, as a class, show that bull-dog muscle that is so noticeable in the Navy man. Otherwise, I think, he will be very much akin to the modern British sailor, officers and crew—there is no higher praise than that.

CHAPTER XVIII

How to Make a Model Monoplane

In the course of this book I have already referred to the building of models as not seeming to be of great use to the inventor. But however that may be, there is no doubt that the construction of a flying machine in miniature can give plenty of amusement and occupation for leisure time, while the subsequent flights accomplished by the little machines are often very pretty to watch.

The building of a model locomotive can be attempted by comparatively few boys. It is an expensive undertaking, as a rule, and, moreover, requires a certain amount of engineering talent to carry through to a successful conclusion, and a good deal of space in the shape of a workroom for the erection of the machine.

The qualities required for the building of a model aeroplane, however, are chiefly deftness and common sense. Then, too, the materials are very cheap, and there is no need for the possession of expensive turning lathes or drills. A parcel of fabric, small spars, nuts, wires, and working drawings can be purchased very cheaply, and with enthusiasm and a little perseverance to carry him on the amateur worker can turn out really beautiful-looking models of standard machines. These models are very often not meant for flying. They

are correct copies of the Blériot or Farman, for exhibition only, and their construction is a task which will give amusement during the winter evenings.

Flying models are very often simpler to build, and there are various works in existence giving instructions in the manner of making sundry flying machines. In case any of my readers should like to try their hands at a simple model, I am reproducing below, from the pages of *Work*, published by Messrs. Cassell and Co., instructions for the building up of a monoplane which should fly if made with suitable care:

"This model monoplane is easily and cheaply made, and can be guaranteed to fly after a little experimenting to get the correct balance and angle of the planes. The frame, A (Figs. 1 and 2), will first be treated. Get two pieces of yellow pine, the lightest and most easily procured wood, cut them to the shape shown, 1 ft. 6 in. long by $\frac{3}{16}$ in. in the middle, and thickened at the ends to take the screws from the end bars, B and C (Fig. 1). Take great care to make them exactly alike. The end pieces, B and C, which are $2\frac{1}{2}$ in. by $\frac{7}{16}$ in. by $\frac{1}{4}$ in., can then be screwed to the side pieces, A, and a rectangular frame is the result. Should the screws split the wood in the slightest degree, new pieces must be made, as the plane is sure to get rough usage by falling heavily on the ground a few times.

"The planes are also made of yellow pine. They must be exactly equal to one another in weight, one being right-handed and the other left.

The wood must not be more than $\frac{1}{32}$ in. thick, and, if possible, even thinner. A large circular chip box will be the best thing from which to make these. Gum a piece of tracing cloth on the top of the planes, and leave about 2 in. overlap at the large ends, to twist and glue round the main frame when fixing. The cloth will fulfil two useful and necessary purposes. It will strengthen the planes and curve them to a very large extent. This curvature is essential to the flight of the machine. A wooden block curved to suit, and inclined at about 5°, is fixed between the back plane and the frame.

"The front, or small plane, is 8 in. by 3 in., and made in the same way as the others. It must be adjustable and is, therefore, mounted on two wooden blocks, 2 in. by $\frac{1}{4}$ in. by $\frac{1}{2}$ in., and fastened by means of copper wire, which acts as a hinge. Four silk cords are fixed to the movable end of the plane, two being fastened to nails at the rear end of the frame and two to the front, to hold the plane at any desired angle.

"The propeller blades (Fig. 4) are made of thin aluminium. Two sheets are cut out the same size and shape, and placed with their ends overlapping (*see* Fig. 5). A piece of steel wire $\frac{1}{16}$ in. in diameter is bent and placed between them to form a shaft. The whole is then fixed on a piece of light copper tube, which is slotted by means of a hack saw or a fret saw to receive them. The blades are bound crosswise to the tube by means of thin wire or strong thread; then twisted to a pitch of about 6 in. It is also advisable to place

a washer between the copper tube and the end bar of the frame.

"The method of fixing the propeller blades (Fig. 5) is not the same as that shown in Figs. 1 and 2, but is the better way.

"The drive for the propeller is elastic, which when twisted and released will rapidly revolve the shaft for a short time. The best kind to use is the grey variety, and when in the form of bands, about 6 in. long by $\frac{3}{8}$ by $\frac{1}{16}$ in., is ready for use without joining. The wires carrying the elastic should be made so that the elastic is just in tension when untwisted.

"The monoplane when complete should be tested without the propeller until it will glide perfectly. The front of the plane will want weight adding if there is a tendency to somersault, but if the back rises quicker than the forward end more weight is necessary there. The propeller should then be tried. . . ."

If the machine is not a complete success, my readers might try building it more lightly, using a wire frame with stretched fabric for the planes. It should be noted that this is a tail-first monoplane.

CHAPTER XIX

Some Undeveloped Types

I HAVE now, I hope, given my readers some idea of the "common or garden" aeroplane, the flying machine which is a familiar sight in flying grounds and is commonly illustrated in the weekly papers. The greatest interest undoubtedly attaches to these aeroplanes. They are flying, and are demonstrating to everyone's satisfaction that they are capable of doing good and efficient work, and for that reason they are to be admired.

Yet it must not be forgotten that aeroplanes of the usual designs are not the only machines in existence to-day, and are not the only machines upon which enthusiastic inventors are spending money and time. There exists in this and other countries an extraordinary number of what may be termed "undeveloped" types of machine. People of little imagination might simply call them freaks, and it must be confessed that there is one remarkably strong argument that can be urged against these miscellaneous models and 'planes. Ask the average exhibitor of a quaint machine if his idea has ever been proved feasible by actual flight, and he will probably say that it has not.

In many cases it must be admitted that the small models have done something. But in the opinion of a good many people aeroplane models

are of little practical use save for the purposes of amusement, since by continual readjustment one can make almost any model leave the ground eventually, although this does not necessarily prove that a full-size machine built on the same lines will follow its example. The big machine has to carry weight, and to meet with a resistance which seems to be out of proportion with the difference in size between it and its little sister!

Another reason for the meagre results which have been attained by machines which are admittedly off the beaten track is that very often their inventors are hampered by a lack of means. Experiments with untried aeroplanes are apt to prove exceedingly expensive, and, in addition, require a great deal of time. The average man has neither the opportunity nor the money to devote to the building of engines, and workshops, and the construction of the various special devices that he may have to employ on his invention. Once a standard type of machine or accessory part has been set up, hundreds of copies can be cheaply turned out to the same pattern, a fact which is very plainly shown by the low cost of the modern bicycle. It is the making of these parts for the first time which runs away with capital.

But it does not follow, because these undeveloped machines have no long flights to their credit and cannot at present compete with a Farman or Bristol, that they are useless or entirely negligible. Some may be the result of rather wild imagination. But many are the fruits of careful calculation and experiment, on a small scale, at any rate.

Ever since Sir Hiram Maxim's great steam aeroplane was produced aerial invention has flourished, and men of all stations of life have made models embodying their own particular theories on the subject of aerial navigation. Perhaps the various stories written by novelists had something to do with this. Be that as it may, it is undoubtedly true that many of these models distinctly resemble in appearance those illustrations which imaginative artists have been accustomed to draw to accompany the letterpress of sundry aerial romances.

Roughly the undeveloped types may be divided into three classes : these are the helicopter, the orthopter and the ornithopter. Of these, the first is the most important.

The helicopter is a flying machine in which vertical screws or helices are used to develop a direct vertical lift for raising the aeroplane beneath them from the ground. A toy used to be sold which gave a good illustration of the theory of this machine. It consisted of a small tin propeller blade, which fitted on to a rod worked in the form of a screw thread. When this blade was pushed quickly up the rod by means of a tin disc it was naturally made to revolve at a high speed, as it passed over the screw thread, so fast that when it worked free of the rod it would ascend to considerable heights, before slowing down and falling to earth. The helicopter is a full-sized adaptation of this idea, and that it is a fascinating idea is shown by the frequency with which it appears in the pages of fiction.

As a fact, however, the construction of a big working machine on these lines presents many difficulties. In the first place, it is easy to see that the helicopter is placed at a disadvantage. When an aeroplane starts, as we know, it rolls along the ground at a gradually increasing speed. The inclination of its supporting surfaces to the air gives it a lift, which becomes more and more powerful as the speed increases, until the whole machine rises from the earth, flying forward at the same time. In the case of the helicopter this does not apply, for since the machine rises vertically into the air it follows that the screws must, by their rapid motion, first generate enough power, or thrust, to overcome the direct pull of gravity which is gluing the machine to the ground. This is a serious handicap, for the power so developed must be very great, and it is hard to obtain a propeller efficient enough to give a suitable lift.

Another difficulty which has often been urged, and should cause inventors to think twice before rashly wasting money, is the difficulty connected with weight and strength. The helicopter screw, if it is to lift a fairly heavy framework direct from the ground, must obviously displace a weight of air equal to that of the machine, plus a certain excess to lift it. Now it is not difficult to understand that a propeller which is powerful enough to do this must be built upon the strongest lines. Its shaft must be fixed in the firmest possible manner in the framework below ; and since great strength means increased weight, it is again evident that the screw will have to be a remark-

ably efficient one if it is to be successful. The number of propellers makes little difference, since each screw still has to raise the strengthened support beneath it.

Workers have from time to time drawn attention to this difficulty. The more powerful the screw, the stronger must be the framework; the stronger the framework, the greater must be the weight, and hence, again, the more powerful the screw required!

In theory, of course, the helicopter is attractive, because its application would give a hovering machine. The aeroplane is handicapped in usefulness by being compelled to keep on the move at a comparatively high rate of speed. For many purposes it would obviously be a great advantage if it were so fashioned that it might be able to heave to and yet stay aloft. If developed successfully, the helicopter would be able to do this; it would, as a rule, have ordinary horizontal screws to give it forward motion, reinforced by the vertical helices for lifting.

In the main, the lines of inquiry which inventors have to follow are fairly plain. They must do their best to discover a thoroughly efficient and powerful propeller, with the correct blades at the correct pitch to give the best possible results. Once that is done, the other questions connected with engine and framework can be solved, since the power of the screw and its lift will be known with certainty, so that the limits beyond which weight must not go will be fixed.

At present, various screws have been tried.

One ingenious invention is the Lorenzen variable pitch screw, which was built for the special purpose of carrying out lifting tests. These screws are mounted upon a very powerful shaft, fixed to a wooden platform, and driven by an electric motor. The pitch of the blade can be altered at will, and the lift developed at certain speeds of revolution is indicated for the benefit of the experimenter. Various pitches of screw have been tested upon this machine, and some very interesting, if technical, data have been gathered regarding the different lifts developed, data which may be of great use in the future development of the helicopter. Mr. Lorenzen designed various screws, one of them being a very large contrivance, consisting of a small inner circle, or hoop, with a larger hoop round it, forming the outer edge. Between the two hoops a number of blades of rectangular shape and variable pitch were fixed, and some good results were obtained with the screw during the various tests that were made.

Apart from testing machines, however, there have been, and are, many helicopters of full size in existence in various workshops all over the world—most of which have done little. One of the quaintest of these in its way, and the most complete, is the Mumford machine. This consists of a very long framework, mounted on wheels; supported vertically on these are no fewer than six helices, two-bladed. These are ingeniously disposed in order to avoid taking up too much room, for since the screw has a total diameter of over 20 ft., it is obvious that, if they were mounted one behind

the other, the framework would have to be of unwieldy size. At the rear of the frame is a fixed triangular rudder, base outwards, to give horizontal steering. In the frame is mounted a 30 h.p. motor, driving a longitudinal shaft, to which the vertical propeller shafts are geared, giving a speed of about forty revolutions a minute to the big screws. The propeller shafts lean slightly forward, the idea being that a vertical lift and a forward thrust are thus obtained together. At the time of writing no information as to trials of this machine was obtainable, but it certainly represents a serious attempt to deal with the knotty problem of the helicopter.

From time to time helicopters of various descriptions have been exhibited at aeroplane shows. One such contrivance, which was really a helicopter and wing machine combined, was the de la Hault. In many respects this was a simpler machine than the Mumford. It consisted of a tubular steel framework carried on four wheels, supporting two triangular sets of tubes. At the apex of each triangle a wing, or screw-blade, was fixed, rather like the blade of a canoe-paddle. A 100 h.p. motor, fixed in the lower chassis, drove these by means of gearing, in such a way that they formed a kind of figure 8 in the air. Alterations in the angles of the wings enabled the machine to be steered. The idea was certainly novel, but has not been developed any further since the date of the machine's exhibition.

Another helicopter which has claims to notice is the Cornu machine. This has actually left the

ground under the power of its helices, although not accomplishing flights which would justify the observer in concluding that the helicopter had at last "arrived." The Cornu machine consists of a wheeled framework holding a motor and fitted with a rudder. At the bow and stern are the two vertical screws—two-bladed.

The "English" helicopter hails from the United States, and is original in design in various respects. This machine, too, has given encouraging results. It consists of a girder framework, running on wheels and supporting two strangely-shaped helices. These in no way resemble the usual screw propeller. Each is formed of two circular discs fitted to the circumference of an iron hoop, and so arranged that the steering can be managed by alteration of the angle at which they are set.

The Rickman machine is also of American origin, and consists of a vast number of planes fitted into a kind of umbrella frame, which revolves above a motor tricycle chassis. The invention has apparently not met with much success.

In a previous chapter it will be remembered that Mr. Grahame-White gave it as his opinion that in the future some sort of machine would be constructed that would combine planes and helicopter, and so give a hovering aeroplane as distinct from the helicopter pure and simple. It is interesting to note that the idea has actually been tried in Germany, and in England a similar machine is said to be under construction. In France quite a number of such machines have been designed, though nothing much has been done with them.

On the whole, it must be admitted that so far, at any rate, the helicopter has not proved itself to be a very practicable type of aerial craft when built on full-size lines, though as a model it will do well. At present it has played a far greater part in fiction than in real life. Possibly it will develop surprisingly in the future, and then there is no doubt that it will have a considerable influence in the design of aerial machines.

To turn to other out-of-the-way types, we have the orthopter, which is a flapping wing machine with flat planes to beat the air. Nothing of importance has been done with this type of machine. The ornithopter is also a flapping-wing machine, with this difference, that the wings are arched like those of a bird. One or two such machines are in existence, while any number of models have been designed. The practical difficulties of building a machine of this type, however, are very great, the power needed to beat a big area of wing surface up and down at any speed being tremendous, while in all probability the difficulties of navigating such a craft in mid-air would be great, the airman's task being complicated by various difficulties of steering and stability. Once again we find that this type of craft has done more in the pages of novels than in the air.

At the Patent Office many specifications of these and other out-of-the-way machines can be seen, representing much thought on the part of their inventors, and being black and white evidence of the interest taken in flight by men all the world over. France, particularly, can show hundreds

of inventions in the making. Probably every possible variation of the flying machine has been tried or planned by the French by this time.

In the case of these flapping wing machines, we find again that models, at any rate, can be made to rise from the ground. Mr. Bastin, an Englishman, built some time ago a model on these lines, which was very successful. But, on the whole, it is safe to say that the encouragement given to inventors of the ornithopter is not great. Their small models may fly a few feet. But in the meantime biplanes and monoplanes of full size are travelling hundreds of miles, so that the ornithopters have a lot of ground to make up before they can meet other machines on equal terms. It is doubtful whether any particular success can be expected of them.

A notable machine that I have not yet mentioned is under construction in England at the time of writing. It is known as the Davidson Gyropter. This is really a machine built on the helicopter principle, and a model of it that was exhibited at Olympia presented a strange and rather romantic appearance. The body of the model was whale-shaped, of metal, and completely enclosed the engines, pilot's accommodation, and passenger seats. In the fore part of the machine were rows of windows, like giant eyes. Behind these eyes, on either side of the machine, projected pairs of wings, and it was between these wings that the helicopter screws—big affairs, of mushroom shape —were fixed. In the full-size machine these are to be driven by steam engines of 60 h.p., and as

this is one of the first helicopters built upon such big and novel lines, it is to be hoped that it will be eventually finished and tested.

Some writers have pictured as the flying machine of the future a contrivance combining the balloon and the aeroplane, the balloon reinforcing the lift of the planes and giving hovering power. This type of machine, too, has not been without its advocates in actual life, and several such airships have been built and designed, although the idea has not found very great favour. The César machine is constructed on these lines, and has made various flights. Owing to the size of the envelope, however, it must be confessed that it presents more the appearance of a dirigible than of a new type of flying machine.

The envelope is fish-shaped, and beneath it are attached the planes, consisting of a biplane machine in the bow, behind which is the motor driving a screw-propeller, and at the stern another biplane, fitted with a rudder for steering, while vertical control is provided for by an elevator in the bow. One or two other attempts of no vast importance have been made in a similar direction, and the type in general does not seem to possess any features of remarkable promise. It is neither airship nor aeroplane, and yet, owing to the presence of an envelope, should, as a rule, labour under much the same disadvantages as the dirigible. It does not seem probable that any great developments in these machines are likely to appear now or in the future.

These are some of the chief undeveloped types,

but there are others that I have not yet touched upon, and there are a number of rather strange-looking variations of more or less standard types of machine. For instance, there is the Phillips, built by the famous experimenter, whose "entering edge" is a byword in aerodynamics. This is the outcome of his early work, and is said to be a multiplane, consisting of a number of narrow surfaces, one above the other, giving a high power of lift. Possibly the type will be developed considerably in the future, so that we may become accustomed to contrivances like overgrown Venetian blinds humming through the air, cloud high above our heads, instead of the usual neat type of aeroplane.

It is curious to note, by the way, that in different countries, different variations of freak machines seem to be popular. The French appear chiefly to favour the helicopter. In the United States multiplanes are popular. Quite the strangest of these is the Roshon, which at first glance looks like a collection of curved and horizontal planes hanging in an iron framework for the inspection of purchasers! As the machine is studied, however, one realises that this is not the idea after all, for a propeller and a motor give the affair a more business-like look. The machine represents in fact an attempt to secure a maximum lift by means of narrow supporting surfaces.

Then there are quadruplanes, with their surfaces arranged in steps, and other designs of multiplanes, with surfaces fitted in varying ways on frameworks.

A strange-looking type of machine which has been built and tried in France is the Givaudan—a tubular aeroplane. In appearance this machine looks like nothing more nor less than a dumb-bell. The bow and stern planes consist of two hoops, or rather drums, hollow and, of course, uncovered at the ends. In the centre of each is a smaller drum, and between the circumferences of the two are set sundry rectangular planes, set all round like the spokes of a wheel inside the larger drum. The drums are mounted upon two pairs of wheels, and are connected by a girder framework of metal tubing, which contains the pilot's seat and a powerful motor, driving a two-bladed tractor propeller beyond the fore drum. The particular advantage claimed by the inventor of this machine is that the plane presents the same area of supporting surface at any lateral angle, so that the cynic who turns his scorn upon the invention may pause to reflect that it possesses, after all, a scientific advantage, despite its strange and not very picturesque appearance.

There are one or two models of somewhat similar machines in existence, some being nothing but cylinders or funnels, with planes on the outside and a screw propeller inside, with rudders and tail as in the ordinary machines.

Such are some of the undeveloped types of aeroplane, but there are many others which it is unnecessary to mention here. There are bat-shaped machines, machines suggesting umbrellas or water wheels. There are variable plane machines and torpedo-shaped flyers, and in workshops

scattered all over Europe there are probably some thousands of models of various descriptions. Yet, save for the helicopter and the multiplane, it is doubtful whether any such machine will ever be sufficiently successful to attract authorities and famous airmen as long as the ordinary aeroplane accomplishes its efficient flights all the world over.

On the whole, one would imagine that it would be better for the clever inventor to devote his attention more to the improvement of the existing successful machines than to the construction of some new ornithopter, which must of necessity make a very small beginning, and is unlikely to equal the performances of the rapidly developing fixed plane supported machine.

Nevertheless there is always the remote possibility of some new and revolutionary machine proving a colossal success. But in the present undeveloped types there seem to be but few clues to such a machine.

CHAPTER XX

Summary

I HAVE now practically reached the end of my trip through the history of aerial navigation, and I hope that my readers have gained some little idea of the progress of flight from the days of Icarus to modern times, though there is a vast amount of material which it is necessary to leave untouched in a book of this description.

As we have seen, development has been a matter of years. It is true that the real history of aerial navigation scarcely begins before the year 1800, but previously to that there had been a long period of dreams, at all events, and of haphazard experiments, even if they were not of a very important description. Then, from 1800 onwards, came the attempts to fly, as distinct from floating in the air. Gradually machines became more scientific, neater in appearance, and more promising. Gliding still further encouraged inventors. The Wright brothers flew—and then, with astonishing rapidity, machine after machine was turned out, record after record broken, and the epoch of flight had really begun.

One of the most surprising facts about this beginning of flight seems to be the calm way in which it is viewed by the public. In some years' time my readers will be glad to think that they

witnessed the first successes in aviation, and lived when the Wrights were making themselves famous. But nowadays people view the aeroplane in a peculiarly matter-of-fact way, are scarcely impressed when one flies over their heads, and rarely take the trouble to read the flying news that is meagrely dished up in their daily paper. Save for a murmur of incredulity when the Wrights first flew, and a crush of sightseers at the flying meetings, aviation made its bow to the world amid a rather disconcerting silence.

The fact is that in this wonderful age of ours science has dazed and confused us by its perpetual discoveries and inventions. As a people we are akin to the man who is conducted through a vast engineering establishment, deafened by the clang of metal, giddy with the sight of flashing steel, dazed with the continual unrolling of new mysteries and wonders. When such a man leaves the " shops " he is too confused to go into ecstasies over a calculating machine, of unimposing appearance and almost human power, in the counting house of the firm !

So we, in the midst of " Dreadnoughts," great guns, engines, medical discoveries, and a thousand other mysteries, have failed to give proper attention to the aeroplane. Enough is as good as a feast, and we are having more than enough.

Then, too, novelists and writers of romance have for years drawn pictures of most marvellous and impossible machines. We have read of flying craft which not only crossed continents, but traversed space and visited other worlds,

and such feats as these make even the best performances of our modern aeroplanes seem rather insignificant. These imaginary ships are as superior to real flying machines as Jules Verne's submarine was to our Navy craft that may be seen on any fine day basking in the sunlit waves off Spithead.

Perhaps the reading of such tales has made us expect too much of our scientists and inventors. It is time writers realised that as good a story can be written about an imperfect aeroplane as about a machine which makes little of a voyage to the moon!

Thus we fail to give due honour to the names of those airmen who have offered their lives to science for the benefit of the world. These are the days of hurry, and we rarely pause to respect the names that go to swell the death-roll from time to time—less frequently now than in the first days of flight. An aviator falls and is killed instantaneously. The few who note his death term him foolhardy, or glibly call him a martyr to science. It would be better to pay a little more respect to the nerve and pluck of the men who are fighting man's battle with the elements, and are daily pushing forward to new ground and learning new lessons which may one day be of the greatest service to humanity. Some of these men may be rash; but none of them lacks pluck, and all of them are working to a great common end, even when flying in competitions. People should respect their great airmen as they respect their great admirals.

It is certain that we can rarely put events in their right perspective until they are past history. But in the future it is probable that these years will be marked as a period of the utmost importance in the world's story—the beginning of a great epoch.

I have already tried to indicate something of the future of flight. It only remains to mark some of the points which seem to await development within the next few years.

One of the most important spheres for development is that of safety. The aeroplane must be made as safe, at any rate, as a railway train, and the airmen and his passengers must not necessarily run more risk than do the passengers in one of our expresses. When such a degree of security is attained flight will become vastly more popular than it is at present. The stability of the aeroplane must be improved so that the chances of upset may be practically negligible; and this degree of stability is already being approached, though, of course, it is some way off at present. Various methods are at present under consideration—pendulums and gyroscopes, for instance. Another method is to provide the airman himself with a means of saving life—by special parachutes and coats, which open out into umbrella form when their wearers leap free from a falling machine.

However, it will undoubtedly be better if the aeroplane is perfected to such a degree that indulgence in any such wild jumps may be unnecessary. Then indeed the hitherto timid section of the "earthmen" will rush to enjoy

the sensation of a voyage in the sky, and the aeroplane will have a wider scope of usefulness.

Another point to which attention is being devoted is the perfection of the slow machine. Doubtless the improvement of the helicopter may have influence in this direction. Meanwhile planes of variable spread or angle of incidence are being attempted, with the idea of giving machines a slow starting or landing speed.

A great field for investigation still awaits the mathematician. Calculations connected with the abstruse mysteries of aerodynamics remain to be worked out; many problems await solution.

The best form of machine, the best plane—these await discovery and proof, while the question of propellers is always a big one. Many shapes and pitches of blade have been tried and are being used at the present day. But as yet the maximum of efficiency is not by any means attained, as far as we can judge, by these varying types, and the inventor and technical man has a great opportunity for fame awaiting him in connection with propellers.

Then the comfort and passenger accommodation of the aeroplane must be developed. Indeed, it is undergoing that process now, as anyone who has studied the latest machines must admit. Armaments also—systems of bomb-dropping and defence against attack—must be improved, while wireless apparatus might be made more compact.

Engines are always improving. But they have a long way to go yet if they are to satisfy the desires of the aviator, combining the maxi-

mum of horse-power and the most excellent efficiency with the minimum of size, weight and "petrol appetite."

There are a similar list of points awaiting the man who puts his trust in the dirigible airship. Engines, envelopes, harbours, propellers—all these want improving if the ship is to become a true liner of the air, ready to start off in any direction and in any weather without danger.

In the immediate future invention may well progress along these lines, gradually improving the aeroplane, and making it safer and more efficient—and, incidentally, more dangerous as a foe. The great question which arises in the mind is—How long will it be before the perfect aeroplane arrives? For arrive it will some day.

It is not easy to answer that question, until it is known exactly what is meant by "perfect." If the word simply implies a high degree of safety, speed, and offensive power, it is possible that such an aeroplane might arrive in a comparatively short time. When we look back and remember how extraordinarily rapid the progress of flight has been within the last two years—how records have been set up and knocked down as regularly as an Aunt Sally at a fair—we can easily imagine that the next ten years may see remarkable developments in the art of flying.

As these lines are written it is announced that Russia is engaged in getting together an aeroplane fleet of 300 machines, that France could call into service 200 'planes in the event of war, and that Germany is intending to devote more attention

to the heavier-than-air craft than she has done hitherto. The fact that such fleets as these are being organised shows the confidence which is placed even now in the aeroplane by Continental authorities.

So far our Government appears to have done comparatively little. But it is time England woke up, just as much in connection with aviation as in connection with certain other questions of defence. It is no use waiting for the perfect aeroplane while big fleets of very capable machines are being massed by nations across the water. We must spend more money on machines as they are and show more enthusiasm in the present art of flying, because the next war may outstrip the perfect aeroplane by a considerable period.

Aviation is a big thing, and it is only by playing the game keenly that we can put our country in the front of nations in the matter of flight. But if we can do that it may be well worth our while. The mastery of the air may mean more than the mastery of the sea in future, and we should lose no chance of helping our airmen to capture and hold it.

CHAPTER XXI

The Recent Progress of Flight

IT is safe to say that during the year 1911 a vast number of people who formerly viewed flight with the eye of the cynic, and looked upon it as a freak pastime, must have been forced to change their settled convictions to some purpose; for, in the history of airmanship, 1911 will be a year famous for great flights.

It is scarcely necessary for me to describe in detail, which is bound to be wearisome, many of the events which made it remarkable; that has already been done by the newspapers, which during these twelve months gave more attention to flight than they have ever done before. But it is advisable to include a sketch of the year's doings, in so far as the requirements of the publishers' arrangements allow, and to bring the history of flight to date, in order that my readers may judge of the great progress that has been made, all over the world, in this, man's newest of accomplishments.

In the first place it may be noted that no epoch-making improvements were made in the aeroplane itself; no inventor came forward with plans for a machine that carried all before it, and reduced flight to the mere pulling of a lever and the operation of a rudder, making it a pastime

for the most nervous of people in every kind of weather. Speaking generally, it may be said that the aeroplane stood still during this period and that the science of airmanship was the sphere in which the greatest improvement was shown.

Sundry alterations, of no vast importance, were, of course, made in machines; and one or two new aeroplanes came to the fore. Among these were the Deperdussin, the Morane-Borel, the British Birdling, and the Austrian Etrich—all of which were entered for the great *Daily Mail* race round England and Scotland.

These machines scarcely need detailed description, for, if we except the Etrich, they all belong, more or less, to standard types of machine.

The Deperdussin is a small monoplane, rather resembling the Antoinette in its general lines; it differs, however, from this famous machine in its landing chassis, and particularly in the tail, which carries a vertical fin, and has not that arrow-like appearance so characteristic of the aeroplane made popular by Hubert Latham.

To all intents and purposes the Morane-Borel and the Birdling machines may be classed as belonging to the Blériot type, as they resemble this best-known of monoplanes very closely.

The Etrich, however, is unique—though it is not unlike the Weiss monoplane already described in this book. It is built almost entirely on the lines of a bird with outstretched wings, the illusion being helped by the horizontal plane in the tail, and the tapering, rounded, and fabric-covered body, carrying the engine and pilot. The wings

sweep boldly back on either side of the airman, are flattened, and then curl up again at the ends in the manner of a gull's pinions, and altogether the machine has a very bird-like appearance. A Daimler engine of 120 h.p. drives the propeller in the bows, and the machine has a remarkable turn of speed; it is even said that in calm weather it has flown at a speed of just upon 100 miles an hour.

Among other machines, already described, the Breguet biplane, and Nieuport monoplane added to their reputations by good work, in the hands of capable pilots.

Early in the summer of 1911, too, the Naval airship was launched, after an unaccountable series of delays caused by trivial mishaps—serious enough, however, to put the great ship temporarily out of action. She was towed out of her shed at Barrow amid much acclamation, and there was a general sense of relief when the press announced that her launch had been successful. Then for some time she lay at anchor in a stiffish breeze, without coming to grief—showing a considerable superiority in this way over the various Zeppelins of ill-fate—but just when the public were expecting to see her aloft, she was taken back to her mysterious harbour; a rumour was circulated that she was to fly at the Coronation Naval Review. But by the end of July, 1911, she had made no further appearance, so that on the whole she may be considered as being as successful as was expected by adherents to the heavier than air machine, and nothing more.

Doubtless, we may yet see her in the air; but my readers must judge for themselves as to whether she is really superior to any first-class aeroplane.

For in addition to many hundreds of straightforward flights the aeroplane has made its mark in "freak" performances.

It has been conned safely through the mists that rise from the rapids of Niagara. This daring and rash flight was made by an American airman, named Lincoln Beachey, on June 28th, and though certainly plucky was at the same time foolhardy. Flying in a Curtiss machine, Mr. Beachey cut through the spray, rising at the very lip of the falls, and then, travelling at a speed of about 50 miles an hour, plunged downwards, sheer into a gorge which was barely 100 feet wide from side to side. When hovering at a height of only 30 feet above the tossing spume of the rapids, he brought his machine up again, landing safely on the Canadian side of the river, after a flight which can truthfully be described as hair-raising.

On the same day a daily paper described how Mr. T. Sopwith, the British airman, overhauled the steamship *Olympic* as she was sailing from New York, and with consummate skill dropped on her deck a parcel which had been ordered by wireless from the liner, flying back again with perfect ease to Long Island.

The Oxford and Cambridge Boatrace, too, gave a number of airmen an opportunity for a novel view of the event. And the crowds on the river bank were vastly pleased when five machines

came roaring overhead, their pilots indulging in a bird's eye inspection of the course.

Partly, perhaps, as a result of this and similar flights, a Bill was passed in Parliament in June forbidding pilots to con their machines over the crowds gathered to view the Coronation; it was realised that any panic caused in a crush of people by the sight of an aeroplane immediately overhead, and possibly in dangerous proximity, might prove disastrous.

It was for this very reason that Mr. Graham Gilmour found himself in trouble with the Royal Aero Club, in July. Early in that month he had conned a Bristol biplane up the Thames, right past the Houses of Parliament, to the great delight of many hundreds of Londoners who viewed his flight from the bridges. Complaints were made that he had flown over the streets, but the Royal Aero Club found on inquiry that this was not the case, as he had taken care to keep his machine well over the river from beginning to end of his journey.

Later on, however, and just before the start for the great *Daily Mail* race, more complaints were made against Mr. Gilmour on the charge of having flown to the danger of the crowds at Henley Regatta. He admitted that he had conned his machine to the river, and brought it down to the very surface of the water, but denied that he had caused any danger to the spectators. The Aero Club, however, thought differently, and to the disappointment of many Mr. Gilmour had his certificate suspended for a month, and was

thus barred from flying in the *Daily Mail* race. This was very unfortunate; and, in the opinion of many people, the suspension might have been postponed, to give Gilmour a chance of flying.

Then, on the Continent, a vast deal of flying was got through, and particularly notable was the work of the French Army pilots, who recorded several remarkable long-distance flights in the course of their duties; and Germany and Russia were not asleep, either, in this matter.

Indeed, it must be confessed, regretfully, that the War Departments of the Continental armies were far ahead of our own Army Office in their treatment of the new science of flight. In the course of this book I have frequently referred to slackness on the part of those in authority to realise the true power and capability of the aeroplane; and this inability to grasp facts of prime importance was never more clearly shown than during the past year. The opinions of airmen of experience, it would be thought, should carry some weight, and in an article in the *Strand Magazine* Mr. Grahame-White pointed out very thoroughly that the aeroplane is already sufficiently developed to make it a useful machine in war, and a possible source of danger to us, island though our country is. But the money spent on aeroplanes by our Army authorities is lamentably small in amount; very few machines are in use at the time of writing; and what is infinitely more important, very few pilots are being trained.

An addition to our war fleet was made by the

gift by Mr. Barber of four "Valkyrie" monoplanes. And it is said at the time of writing that two of these machines will be placed in the hands of the Navy men; and it is also said that the Army are to have a Breguet machine to experiment with; but these five aeroplanes make but a poor appearance beside the fleets of hundreds that are being used and ordered abroad.

Now, the argument of the authorities is that the aeroplane is at present undeveloped, and that it will improve. Doubtless that is so; but the events of 1911 show us very conclusively that the aeroplane is a great deal more efficient than is generally supposed. If proof is needed, let us examine briefly the history of the year.

One of the first flights to open people's eyes to the progress of airmanship was that made by M. Prier on April 12th, 1911, from the Hendon Aerodrome to Paris, without a stop. The distance covered was some 250 miles, and the average speed for the whole journey amounted to no less than 63 miles an hour, the time taken being three hours and fifty-eight minutes. In other words, M. Prier travelled from one capital to the other between lunch and tea time, in about half the time taken by the fastest express service. The machine used was a 50 h.p. Blériot-Gnome monoplane.

Cosily dressed, and padded with wool, M. Prier got off from Hendon at 1.37 p.m. in fine sunny weather, and flying clear of London crossed the Thames at Chatham and made for Dover, keeping at an altitude of 1,800 to 2,000 feet. Heading

across Channel in a tricky wind he rose to a higher elevation, trailed his shadow over the coast of France, ran into a mist, and eventually, when his eyes were beginning to pain him somewhat—he was not wearing protective goggles—arrived at Paris at 5.35 p.m., descending in perfect safety at the suburb of Issy-les-Moulineaux.

He had created a record and made a very fine flight at one and the same time.

A much easier, but none the less impressive, flight was made on May 6th by four airmen in England—Messrs. Hamel (Blériot monoplane), Snowden-Smith (Bristol biplane), Graham Gilmour (Bristol biplane), and Pixton (Roe biplane). These four raced from Brooklands to Brighton, all finishing in safety, and without difficulty, and delighting thousands by an exhibition of flying round the pier head. That very popular young airman, Gustave Hamel, was the winner; and it may be mentioned that after the race he flew back from Brighton to Brooklands in the astonishingly short time of thirty-six minutes.

But greater than all these were the flights made in the five big races of the year. These contests were the Paris-Madrid, won by the Frenchman Vedrines, the Paris-Rome, won by Lieutenant Conneau of the French Navy on a Blériot, the Circuit of Europe race, and the *Daily Mail* £10,000 Circuit of Britain contest, won by the same pilot, and the Gordon-Bennett race, won by Weymann of America, on a Nieuport monoplane.

A too-detailed account of these races would be wearisome, and I shall therefore only refer to

them briefly. Starting at the end of May, the Paris-Madrid race was divided into three sections. These were Paris-Angoulême, 250 miles; Angoulême-San Sebastian, 208 miles; and San Sebastian-Madrid—about 269 miles. Big prizes were offered by various journals, and it must be confessed that they were earned, for the course was of a difficult nature, and comprised various types of flying hazards, including mountains, where the winds were very tricky.

M. Vedrines, who, by the way, was a mechanician to the English airman, Mr. Loraine, before he started to fly on his own account, was using a Morane-Borel monoplane; he showed splendid airmanship all the way through the race, and won fairly easily, his net air time being 12 hours 18 minutes for 726 miles, roughly; his average speed, therefore, was about 59 miles per hour. Only four airmen started for the race, and all save Vedrines met with difficulties and mishaps; the latter, too, had his adventure, for when flying through the mountain pass of Somosierra his aeroplane was attacked by an eagle. Fearing that the bird might dash itself at his face, and cause him to lose control of the machine, Vedrines was forced to employ tricks of airmanship to avoid it, and he eventually succeeded in shaking his enemy off by rising quickly, and then bringing his machine down again in a *vol plané*. Finally, after a cold and dangerous journey, Vedrines won, being received with enthusiasm at Madrid, where he was subsequently decorated for his flight by King Alfonso.

The Paris-Rome race started early in June, and was less exciting in various ways than the previous contest. It was won, as stated, by Conneau, or "Beaumont," as he called himself—time 82 hours 5 minutes. Garros, like the winner, using a Blériot, was second; Frey, on a Morane, third; and Vidart, on a Deperdussin, fourth. Vedrines had the bad luck to smash his machine during the race, in making a bad landing.

The flight for the Gordon-Bennett Cup took place at Eastchurch on July 1st, and unfortunately the trophy was taken from England by Weymann, of America, who completed the 94 miles in 71 minutes 36 seconds, in a 100 h.-p. Nieuport-Gnome. Leblanc, of France, was a close second, flying in a 100 h.-p. Blériot-Gnome; he made a very sportsmanlike effort to catch the winner, making his turns at a wonderful speed. The wings of his machine had been clipped, in order that, by reducing its plane area it might be rendered swifter. The plan probably had this effect, for Leblanc finished with the creditable time of 72 minutes 40 seconds to his credit. Third came M. Nieuport, of France, on one of his own machines—time, 73 minutes 40 seconds; and fourth was Alec Ogilvie, of the British team, who used a Wright biplane. But as was to be expected, his machine was much slower, and his time at the finish amounted to 109 minutes 10 seconds. During the race, Gustave Hamel, who was flying a Blériot in the English team, met with an accident, his machine coming to earth when he was rounding a turn, and being badly smashed. He himself

was shaken, but fortunately not seriously injured; authorities attributed his accident to the fact that he, too, was using a machine with shortened wings, to which he was not accustomed.

The Circuit of Europe race started in the middle of June, and the competitors had a distinctly ambitious programme before them. There were nine long stages in the race, which started at Paris, passed Liège, Utrecht, Brussels, Roubaix, Calais, London, Calais again, and finished at Paris; and the prizes offered for various stages amounted to a very considerable sum. The original entries numbered some fifty-two machines of nearly every Continental type, in addition to two Bristol biplanes, and the race was in many ways a big event.

Unfortunately, it had a most disastrous opening, on Sunday, June 18th. When flying to the aerodrome for the start, Lieutenant Princeteau's monoplane capsized and fell, causing the petrol tank to burst. In a moment the aeroplane was in flames, and to the horror of the spectators it was seen that the airman was pinned beneath the wreckage; and he was burned to death before help could reach him. Later on, almost immediately after starting for the race, an airman named Lemartin, flying a monoplane, fell like a stone from a height of some 200 feet, sustaining terrible injuries which caused his death. Still later M. Landron, in a Pischoff monoplane, fell at Château Thierry, was pinned beneath his machine, and suffered a similar fate to that of Lieutenant Princeteau, his machine blazing up

like tinder. In addition, another airman was badly injured by a fall in a wood. Nevertheless, the rest of the competitors continued on their way, flying well before a huge concourse of people, massed at all points of vantage on the route.

To describe the race in detail would be wearisome. Suffice it to say that the number of competitors was rapidly reduced as the various stages were flown; and when the London stage was reached only ten airmen crossed the Channel. The spectacle at Dover, however, in the early morning, was magnificent, as many as five machines being visible at one time, racing neck and neck across the grey sea in the early morning. Nine of the airmen arrived safely at Hendon, the purring of their engines waking many sleeping inhabitants of the South of England during their flight; the first arrival was Vedrines, but most of the others were not far behind him.

Then came the final stages of the race, the return to France in the early morning from Hendon, and the flight to Paris—all very well carried out, leaving Lieutenant Conneau, the winner, with Vedrines close behind him. And after that interest began to centre on the second £10,000 race organised with splendid enthusiasm by the *Daily Mail*—a race round England, and through part of Scotland, a race which promised to be the stiffest test airmen had ever been put to carry out.

This air race was a remarkable test of airmanship and efficiency, and was without a doubt a

better test for the machine than had ever been suggested before, for the following reason :

In all previous air races, the contest had been between men more than between machines ; an airman might, for instance, have flown 100 miles or so, and then have damaged his plane beyond hope of repair. But there was no necessity for him to be cast down, were that the case ; for he had merely to telegraph to his mechanics, and down they came with a new machine, or a new engine, and off went the pilot, fitted out again to compete in the race.

The rules under which the Circuit of Britain race were flown made such happenings impossible ; for before the start five essential parts of aeroplane and engine were officially stamped by the Royal Aero Club, and these were not permitted to be removed or replaced during the contest, although certain other less important parts could be changed if necessary

The route was divided into controls—these being as follows : The first stage was a short one, a kind of preliminary canter from Brooklands to Hendon. This was flown on Saturday, July 22nd, in terrifically hot weather, and before a crowd that was unequalled for numbers and enthusiasm by any previous meeting of any description at Brooklands track. Seventeen pilots finished the stage, many of them finding the heated air very tricky to navigate, as any number of " pockets " were developing ; and the dense crowds along the route from Walton to Hendo had splendid views of many different types of aeroplane in full flight.

Among these machines were Blériots, Breguets, Bristols, a Grahame-White "Baby," a Cody, Deperdussin, Morane-Borel, Nieuport, Blackburn, Birdling, and Howard-Wright; the actual fastest time was made by Weymann on his Nieuport, for he covered the distance of 20 miles in 14 minutes. But previously to that, he had crossed the starting line and been delayed, so that a large addition was made to his actual flying time. As a result, Vedrines, Lieutenant Conneau, and Hamel headed the list of arrivals at Hendon, when the first stage was done and the crowds had finished cheering the superb flying of the airmen, as one after another, in rapid succession, they appeared in the distance as specks, grew larger, and dipped gracefully down to the turf of the aerodrome. Then the airmen prepared for the long second stage.

At four o'clock on a dull Monday morning the machines got off from Hendon, and headed north for Harrogate, Newcastle, and Edinburgh, where the second stage finished.

Though grey and dispiriting, the weather was not by any means unfavourable for flying, and a vast crowd assembled, despite the early hour, to witness the start of the airmen on their long journey. Thousands thronged the fields at Hendon, climbing on to railway embankments, hedges and gates; the road between Golder's Green and Hendon was crowded from three o'clock in the morning, when dawn was just breaking, and motors, cycles, and taxicabs buzzed towards the aerodrome, hurrying to be in good time for the flying.

The number of French people in the crowd was extraordinary, and it is not surprising, therefore, that when, with a roar, Conneau's Blériot left the ground, followed at once by Vedrines' Morane-Borel, the countryside echoed with cheering. One after another the aeroplanes trundled forward, and rose, floating beautifully away, until they had vanished in the distance, and then the tired spectators made their way home to breakfast, and waited for news of the pilots, hurrying along, so lonely and yet so much to be envied, above the towns and fields.

Before the end of the day it was evident that a number of the competitors were out of the race. The line of aeroplanes had already strung out, and there had been one or two accidents—only the machines being hurt, fortunately. All these mishaps were caused by rough landing, but the responsibility for failure rests in most cases on the engines.

Meanwhile, however, excellent work had been done, many of the airmen having been forced to fly very low down in a thick fog. At eleven o'clock in the morning Vedrines had landed gracefully at Edinburgh, after being met with wild enthusiasm at Harrogate and Newcastle; he was followed in a quarter of an hour by Lieutenant Conneau; and four hours later Mr. Valentine, on a Deperdussin, came into sight, having been delayed by bad weather, and a stiff wind which had blown him out of his course.

Hamel, who only travelled as far as Newcastle, had the worst luck, a trivial defect in his engine

delaying him for hours while his competitors passed him; and on finally arriving at Newcastle, he showed manifest signs of great physical strain. Cody, after bursting a petrol tank in mid-air, arrived at Harrogate, and stayed for repairs, and the rest of the airmen were all short of the Yorkshire town, delayed for varying reasons.

On the next day the flight from Edinburgh to Manchester and Bristol, via Glasgow and Stirling, was made; and henceforth the contest became a duel between Conneau and Vedrines. And a memorable duel it was.

You can picture those two goggled, muffled airmen, crouching over their wheels, blown this way and that by furious gusts in the mountain gorges of Scotland, so that at times their aeroplanes barely moved; tossed like leaves in the gale; lashed by rain and hail that fell from the grey skies; air-sick, numbed, and weary, yet holding steadfastly to their work, listening anxiously to the beat of their engines, and operating their controls with deft hands as they drove over hill and dale—southward-ho! A more wild and picturesque race than this has surely never been won.

Steadily and surely the two men flew, now rising high above the hills, now dipping into the valleys; and everywhere watched by vast and wondering crowds. South and further south! Manchester was reached, and the men headed for Bristol; Vedrines was losing time, and, by sheer bad luck, he was destined on that last stage of the day to lose the race. Conneau reached Bristol

and landed; but Vedrines was nowhere in sight, and bonfires were hastily kindled to light him to the aerodrome, for it was known that he was flying hard for the goal. Nevertheless, despite these precautions, he lost his way, and was over fifty minutes late when he came to earth. Previously to that he had lost time by missing the Glasgow control.

This gave Conneau the advantage, and with Vedrines the only man to threaten him—for Valentine had broken his propeller in Scotland—he looked like winning. The last stage of the race was splendidly flown. Getting early away from Bristol, Conneau flew steadily to Exeter, Salisbury and Brighton, while Vedrines with smoking engine and roaring propeller made desperate efforts to overhaul the leader's time, and did gain a few minutes.

But Conneau made no mistake on his last trip to Brooklands, and flying easily and surely, arrived to be greeted by a vast and enthusiastic crowd; and his rival hove in sight shortly afterwards, beaten, but far from dishonoured.

Thus ended the great race, and it had a fitting sequel in His Majesty's reception of the winning airman at Buckingham Palace a day later.

PRINTED BY CASSELL & COMPANY, LIMITED, LA BELLE SAUVAGE, LONDON, E.C.